AN ECONOMETRIC MODEL OF STRUCTURAL CHANGES IN THE U.S. POTATO INDUSTRY

BY

EUGENE JONES

A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL
OF THE UNIVERSITY OF FLORIDA IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1984

To the memory of my father
who comitted his life to providing
educational opportunities for
his children

ACKNOWLEDGEMENTS

I wish to express a sincere and profound gratitude to my committe chairman, Dr. Ronald W. Ward, for his guidance, counsel and encouragement throughout my research studies. Dr. Ward always seemed to give me a larger proportion of his time than that which could be justified, given his other research and teaching responsibilities. His enthusiasm for the subject and his dedication to his profession were kindles of spark that inspired me to keep trying even in the face of what seemed like insurmountable hurdles.

I am also grateful to Dr. Glenn Zepp for his assistance in providing data and information through the Economic Research Service, U.S.D.A., and his comments and suggestions for improving the manuscript. To the other members of my committe, Drs. Richard Kilmer, Frank Martin and W. W. McPherson, I am appreciative for their reviews and suggestions for strengthening the research. I am also thankful to Dr. McPherson for his guidance and assistance during much of my course work, especially assistance in obtaining funds. The suggestions and comments of Dr. Henry Fishkind during the initial stages of this research are also appreciated. The Economic Research Service is due a special note of thanks for funding the research.

I am also grateful to my typists: Kathy Carroll, Linda Kilmer and Kathleen Laird. The patience and skills exemplified by these persons are much appreciated. I am also thankful for my friends and associates who helped to make my studies more pleasant and rewarding.

To the most important people of my life, my wife, Jackie, and daughter, Lauren, I owe a special note of gratitude for their encouragement, support and sacrifice. Jackie's uncanny ability to offer words of encouragement during stressful times proved more effective than any medicine she ever prescribed for me. Lauren's little gentle smile was a great source of comfort after a long and difficult day of work. The ultimate note of gratitude is owed to my mother, Pauline, who taught me the important things of life.

TABLE OF CONTENTS

Page

ACKNOWLEDGMENTS iii
LIST OF TABLES viii
LIST OF FIGURES x
ABSTRACT xiii

CHAPTERS

I INTRODUCTION 1
Product Characteristics 1
Demand and Supply 2
Structural Attributes Within the Potato Market 8
Structural Attributes Outside the Potato Market 15
Concept of Performance 21
Criteria for Analyzing Performance 21
General Performance of Potato Industry 23
Problem Statement 29
Hypotheses 34
Objectives 34
Methodology and Scope 35
Subsequent Chapters 36

II LITERATURE REVIEW 38

Introduction 38
Previous Studies 38
Least Comprehensive Studies 39
Moderately Comprehensive Studies 42
Comprehensive Studies 46
Present Study 56

III OVERVIEW OF POTATO INDUSTRY 58

Introduction 58
Potato Production 58
Potato Consumption 62
Fast Food Establishments 64

CHAPTERS Page

Women in The Work Force 67
Population 68
Number and Size of Households 68
Consumers Taste 69
Implications 69
Summary and Conclusion 73

IV DEVELOPMENT OF ECONOMIC MODEL 76

Introduction 76
The Structural Sector 77
  Number of Potato Processing Plants 82
  Concentration in Potato Processing 86
  Price Cost Margins 89
  Advertising Sales Ratio 90
  Change in Processing Capacity 93
  Utilization of Processing Capacity 93
The Market Equilibrium Sector 95
  Production of Raw Potatoes 95
  Utilization of Potatoes for Fresh Consumption 97
  Utilization of Potatoes for Processing 100
  Retail Price of Fresh Potatoes 104
  Retail Price of Processed Potatoes 105
  Wholesale Price of Processed Potatoes 105
  Farm Price of Raw Potatoes 106
  Research and Promotion Tax 107
  Spread Between Retail and Farm Price 107
  Utilization of Total Production 108

V ECONOMETRIC MODELLING OF THE POTATO SUBSECTOR 110

Multicollinearity 110
Principal Components 113
Principal Components in Simultaneous Equations 117
Principal Components in Present Study 121

VI OPERATIONALIZING THE POTATO MODEL 127

Introduction 127
Parameter Estimates and Their Properties 128
Structural Equations Results 135
  Number of Processing Plants 135
  Concentration in Processed Potato Production 141
  Price Cost Margins 145
  Advertising Sales Ratio 146
  Change in Capacity 149
  Utilization of Capacity 150
Significance of Structural Results 152
Market Equilibrium Results 154

CHAPTERS Page

Production of Fresh Potatoes 155
Utilization of Fresh Potatoes 156
Utilization of Processed Potatoes 163
Retail Price of Fresh Potatoes 166
Retail Price of Processed Potatoes 167
Farm Price of Fresh Potatoes 168
Significance of Market Equilibrium Results ... 168
Summary of Structural and Market Equilibrium Results 171

VII USING THE MODEL 175

Introduction 175
Performance of The Model 175
Reduced and Final Forms 175
Reduced and Final Forms for Structural Equations 178
Reduced and Final Forms for Market Equilibrium Equations 190
Synopsis of Structural and Market Equilibrium Results 212
Model Forecasts 214
Theory of Forecasting 214
Structural Equations Forecasts 216
Market Equilibrium Equations Forecasts ... 222

VIII IMPLICATIONS OF MODEL 229

Introduction 229
Policy Evaluation 229
Policy Simulation Results 233
Conclusion 265

APPENDICES

A DISCUSSION OF DATA 266

B DATA SOURCES 280

C RAW DATA AND SOME EMPIRICAL RESULTS 285

REFERENCES 309

BIOGRAPHICAL SKETCH 315

LIST OF TABLES

Tables | | Page
1.1 U.S. Potato Production and Yield by Region, 1950-80 4

1.2 Changes in U.S. Potato Production by Region, 1950-80 5

1.3 Potatoes: Total U.S. Production and Prices, 1950-82 6

1.4 U.S. Away-From-Home Food Expenditures 20

3.1 U.S. Potato Production by Region, 1950-80 60

3.2 U.S. Per Capita Consumption of Fresh and Processed Potatoes, 1950-80 63

4.1 System of Equations for Analyzing the U.S. Potato Industry 79

5.1 Correlation Coefficients 123

5.2 Eigenvectors 124

6.1 Parameters and Statistics for Structural Equations 137

6.2 Parameters and Statistics for Market Equilibrium Equations 157

6.3 Estimated Parameters for System of Equations in U.S Potato Subsector 173

8.1 Simulation Results: Impact of Policy Variables on Selected Endogenous Variables .. 234

8.2 Simulation Results: Impact of 3 Percent Changes in Policy Variables on Selected Endogenous Variables 235

8.3 Simulation Results: Impact of 6 Percent Changes in Policy Variables on Selected Endogenous Varables 236

Tables Page

A.1 Variables For Analysis of Potato Industry 268

C.1 States Comprising Potato Production Regions ... 286

C.2 Principal Components Analysis 287

C.3 Principal Components Equations 290

C.4 Second and Third Stage Estimates 292

C.5 Demand Elasticities 297

C.6 Long and Short Terms Multipliers 298

C.7 Root Mean Square Errors 301

C.8 Raw Data for Analysis of Potato Subsector 302

C.9 Simulated Effects of Specific Policy Variables 306

LIST OF FIGURES

Figures Page

1.1 Percent Changes in Consumption of Processed Vegetables with Comparison to Potatoes 27

1.2 Changes in Consumption of Seven Major Processed Vegetables with Comparison to Potatoes 28

1.3 Consumption of Frozen Vegetables with Comparison to Potatoes 30

3.1 Fast Food Establishments by Number and Sales 66

4.1 Schematic Diagram of Potato Industry 78

6.1 U.S. Potato Production by States, 1950 142

6.2 U.S. Potato Production by States, 1980 143

7.1 Actual, Predicted and Simulated Values for Potato Processing Plants 179

7.2 Actual, Predicted and Simulated Values for Concentration 182

7.3 Actual, Predicted and Simulated Values for Prices Cost Margins 183

7.4 Actual, Predicted and Simulated Values for Advertising Sales Ratio 185

7.5 Actual, Predicted and Simulated Values for Changes in Processing Capacity 187

7.6 Actual, Predicted and Simulated Values for Utilization of Processing Capacity 189

7.7 Actual, Predicted and Simulated Values for Production of Fresh Potatoes 191

7.8 Actual, Predicted and Simulated Values for Utilization of Fresh Potatoes 193

Figures Page

7.9 Actual, Predicted and Simulated Values for Utilization of Processed Potatoes 195

7.10 Actual, Predicted and Simulated Values for Farm Price of Fresh Potatoes 197

7.11 Actual, Predicted and Simulated Values for Wholesale Price of Processed Potatoes 199

7.12 Actual, Predicted and Simulated Values for Retail Price of Fresh Potatoes 201

7.13 Actual, Predicted and Simulated Values for Retail Price of Processed Potatoes 203

7.14 Actual, Predicted and Simulated Values for Spread of Retail and Farm Price 206

7.15 Actual, Predicted and Simulated Values for Research and Promotion Tax 207

7.16 Actual, Predicted and Simulated Values for Utilization of Other Potatoes 209

7.17 Percent Changes in Farm Price and Farm Production of Potatoes 210

7.18 Percent Changes in Retail Fresh Price and Farm Production of Potatoes 211

8.1 Simulated Effect of Transportation Cost Potato Processing Plants 239

8.2 Simulated Effect of Minimum Efficient Plant Size on Potato Processing Plants 240

8.3 Simulated Effect of Advertising Sales Ratio on Consumption of Processed Potatoes 241

8.4 Simulated Effect of Advertising Sales Ratio on Price Cost Margins 243

8.5 Simulated Effect of Fast Food Consumption on Consumption of Fresh Potatoes 244

8.6 Simulated Effect of Fast Food Consumption on Consumption of Processed Potatoes 245

8.7 Simulated Effect of Non-Fast Food Consumption on Consumption of Fresh Potatoes 247

Figures Page

8.8 Simulated Effect of Non-Fast Food Consumption on Consumption of Processed Potatoes 248

8.9 Simulated Effect of Women in the Labor Force on Consumption of Fresh Potatoes 250

8.10 Simulated Effect of Women in the Labor Force on Consumption of Processed Potatoes 251

8.11 Simulated Effect of Population on Consumption of Fresh Potatoes 252

8.12 Simulated Effect of Population on Consumption of Processed Potatoes 253

8.13 Simulated Effect of Income on Consumption of Fresh Potatoes 255

8.14 Simulated Effect of Income on Consumption of Processed Potatoes 256

8.15 Simulated Effect of Minimum Efficient Plant Size on Concentration 257

8.16 Simulated Effect of Minimum Efficient Plant Size on Price Cost Margins 258

8.17 Simulated Effect of Minimum Efficient Plant Size on Advertising Sales Ratio 259

8.18 Simulated Effect of Minimum Efficient Plant Size on Consumption of Fresh Potatoes 260

8.19 Simulated Effect of Minimum Efficient Plant Size on Consumption of Processed Potatoes ... 261

8.20 Simulated Effect of Minimum Efficient Plant Size on Wholesale Price of Processed Potatoes 262

8.21 Simulated Effect of Minimum Efficient Plant Size on Retail Price of Processed Potatoes .. 263

Abstract of Dissertation Presented to the Graduate Council
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosopy

AN ECONOMETRIC MODEL OF STRUCTURAL CHANGES IN THE U.S. POTATO INDUSTRY

By

Eugene Jones

August 1984

Chairman: Ronald W. Ward
Major Department: Food and Resource Economics

The U.S. potato industry during the past two decades experienced dramatic economic changes in both its structural and market equilibrium characteristics. Exogenous and endogenous forces interacted to shape these transformations within the industry.

The primary objectives of this study were (a) development of an econometric model that captured and explained the adjustments noted above, (b) determination of the future of the industry, and (c) evaluation of the impacts of policy variables on the industry. A sixteen equation simultaneous system was developed and estimated using three stage least squares (3SLS). Because high correlation was noted among many variables, principal components were derived from the original variables and used in the first and second stages of estimation. Identification of the endogenous variables estimated with principal components was maintained by carrying the endogenous parts of the principal components as additional equations in the system.

The empirical results indicate a relationship between the structural and market equilibrium characteristics, but not always a direct relationship. Increased demand for processed potatoes, for example, served not to increase but to decrease the number of plants or firms processing potatoes. As firms left the industry, concentration among the top four potato processors increased. The results further indicate increased advertising intensity with increased concentration. Empirical results for the demands for fresh and processed potatoes indicate a strong preference by consumers for processed over fresh potatoes. The retail price of fresh potatoes has little impact on demands for either fresh or processed potatoes. Demands for both fresh and processed potatoes, on the other hand, are influenced by the price of processed potatoes.

The quantified model was used to both forecast supply, demand, and structural changes through 1990 and to study the sensitivity of the industry to specific exogenous changes. Explicit policy issues were identified and simulated.

CHAPTER I
INTRODUCTION

Product Characteristics

Agricultural commodities are bought and sold in markets. These markets are in essence a system of communication for transmitting consumers' demands to producers and producers' supplies to consumers. During this communication, market prices are established which, in turn, become the primary medium of communication between producers and consumers. A single price may be established for those commodities produced and sold in closely defined geographic areas where buyers and sellers are in immediate communication with each other. Multiple prices, however, most often characterize those commodities which are bought and sold in widely dispersed geographic areas where intimate communication between buyers and sellers is absent.

Potatoes, the commodity of interest in this study, are characterized by multiple prices with respect to time, place and form. Given a perfect market for potatoes, that is, "all buyers and sellers in it have perfect knowledge of demand, supply, and prices and act rationally upon that knowledge . . . the price differential in time, place, and form would be equivalent to the corresponding differences in costs" (Shephard and Futrell, p. 24). Given that perfect markets for potatoes do not exist, one would expect some disparity between price and production cost. Price-cost disparity may be due to incomplete or inaccurate information, the existence of market power by buyers and sellers, preferences on the part of buyers for particular commodities, risk and uncertainty regarding the future, and so forth. To the extent that price-cost differentials exist, economic resources are allocated in a nonoptimal or inefficient manner.

Price discovery with respect to product form will be of considerable interest in this study as fresh and processed potatoes are analyzed. Ideally, one would expect competition in the potato market to equate the net value of processed potatoes, less processing cost, to the price of fresh potatoes. This ideal situation may be inhibited by several market imperfections. Among these are processors' market power, potato growers' incomplete knowledge of processing cost, negotiated contract prices for fresh potatoes, advertising persuasion, and consumers' susceptibility to fancied product differentiation.

Demand and Supply

The supply of potatoes in the U.S. is limited primarily by demand constraints. Potato producers have continually had to restrict their acreage as technological advances have greatly augmented yields. Average yields per acre have increased from 153 hundredweights (cwt) in 1950 to 262 cwt in 1980, an annual increase of 2.3 percent; acreage in production has declined 1 percent annually since 1950. Total consumption of potatoes also has increased by an annual rate of 2.3 percent since 1950. And while total increases in demand and supply have been moderate, there have been dramatic shifts in supply areas and supply utilization.

Historically, potato production in the Northeast has been among the highest in the nation, with Maine being the primary producing state. In 1950, for example, 29 percent of U.S. potato production occurred in the Northeast; average yields were 212 cwt as opposed to 197 cwt in the Pacific Northwest, the major competitor of the Northeast (Tables 1.1 and 1.2). By 1980, average yields in the Northeast had increased to 236 cwt while its production amounted to only 14 percent of U.S. total. By contrast, average yields in the Pacific Northwest had risen from 197 cwt in 1950 to 331 cwt in 1980; production as a percentage of U.S. total had risen from 17.6 percent to 47 percent. These relative changes together with those occurring in other regions increased U.S. total production from 259.1 million cwt in 1950 to 302.8 million cwt in 1980. This 1980 production was considerably below 1979 production of 342.5 million cwt, and even further below 1978 production of 365.2 million cwt (Table 1.3). The low potato production of 1980 coupled with an inelastic demand for potatoes generated net farm income to potato producers far in excess of the income generated the previous two years. This higher income resulted from

Table 1.1--U.S. Potato Production and Yield by Region, 1950-80

Region	1950		1960		1970		1980	
	Production (1000 cwt)	Yield per acre (cwt)	Production (1000 cwt)	Yield per acre (cwt)	Production (1000 cwt)	Yield per acre (cwt)	Production (1000 cwt)	Yield per acre (cwt)
Northeast	76,127	212	66,973	225	64,575	244	42,193	236
Middle Atlantic	19,327	121	15,469	165	11,330	164	7,010	153
Southeast	11,769	69	10,320	101	9,388	135	6,719	145
Lake States	25,171	121	22,225	178	29,026	240	28,705	267
Red River Valley	22,632	110	27,751	128	30,940	145	27,166	150
Pacific Northwest	45,551	197	60,991	200	123,479	264	143,520	331
California/Nevada	28,252	231	28,777	279	29,760	340	23,112	364
Central	30,283	124	24,398	172	27,254	200	24,432	251
U.S. Total	259,112	153	257,104	185	325,752	228	302,857	262

Source: _Potatoes and Sweetpotatoes_, Crop Reporting Board, USDA, 1950-80.

Note that states comprising each regions are delineated in Table C.1.

Table 1.2--Changes in U.S. Potato Production by Region, 1950-80

	Production as % of U.S. Total				Percent change in yield per acre		
Region	1950	1960	1970	1980	1950-1960	1960-1970	1970-1980
Northeast	29.4	26.1	19.8	13.9	6.1	8.4	-3.3
Middle Atlantic	7.5	6.0	3.3	2.3	36.4	-.6	-6.7
Southeast	4.5	4.0	2.9	2.2	46.4	33.7	7.4
Lake States	9.7	8.6	8.9	9.5	47.1	34.8	11.3
Red River Valley	8.7	10.8	9.5	9.0	16.4	13.3	3.4
Pacific Northwest	17.6	23.8	37.9	47.4	1.5	32.0	25.4
California/Nevada	10.9	11.2	9.1	7.6	20.8	21.9	7.1
Central	11.7	9.5	8.4	8.1	38.7	16.3	25.5
Total	100.0	100.0	100.0	100.0			

Source: Potatoes and Sweetpotatoes , Crop Reporting Board, USDA, 1950-80.

Table 1.3--Potatoes: Total U.S. Production and Prices, 1950-82

			Percentage Change from Previous Year	
Year	Production	Average Farm Price	Production	Price
	million/cwt	Dollars/cwt	Percent	
1950	259.0	1.50	3.6	-28.6
1951	195.8	2.68	-24.4	78.7
1952	211.1	3.21	7.8	19.8
1953	231.7	1.31	9.8	-59.2
1954	219.5	2.15	-5.3	64.1
1955	227.7	1.77	3.7	-17.7
1956	245.8	2.02	7.9	14.1
1957	242.5	1.91	-1.3	-5.4
1958	266.9	1.31	10.1	-31.4
1959	245.3	2.27	-8.1	73.3
1960	257.1	2.00	4.8	-11.9
1961	293.2	1.36	14.0	-32.0
1962	264.5	1.67	-9.8	22.8
1963	271.2	1.78	2.5	6.6
1964	242.1	3.50	-11.1	96.6
1965	291.1	2.53	20.7	-27.7
1966	307.2	2.05	5.5	-19.0
1967	305.0	1.87	-0.7	-8.7
1968	295.4	2.23	-3.1	19.3
1969	312.4	2.23	5.7	0
1970	325.7	2.20	4.2	-1.3
1971	319.3	1.90	-2.0	-13.6
1972	296.4	3.01	-7.2	58.4
1973	300.0	4.89	1.2	62.4
1974	342.4	4.01	14.1	-18.0
1975	322.3	4.48	-5.9	11.7
1976	357.7	3.59	11.0	-19.9
1977	355.3	3.55	-.7	-1.1
1978	366.3	3.38	3.1	-4.8
1979	342.5	3.43	-6.5	1.5
1980	302.9	6.55	-11.6	91.0
1981	338.6	5.41	11.8	-17.4
1982	349.3	4.45	3.2	-17.7

Source: Vegetable Outlook and Situation, USDA, July, 1983.

average potato prices of $6.55 per cwt in 1980 as opposed to $3.40 for 1978-79 (Table 1.3).

Just as dramatic as the supply shifts from the Northeast to the Pacific Northwest are changes in utilization of this supply. Processed potatoes (chips, dehydrated, frozen, etc.), while comprising 6 percent of total potato consumption in 1950, rose to 61 percent in 1980. This represents an increase in per capita consumption of processed potatoes from 6.3 pounds to 64.4 pounds, fresh-weight equivalent. By way of comparison, fresh potato consumption declined during this period from 100 pounds to 51.4 pounds per capita.

From 1950 to 1965, increases in per capita consumption of processed potatoes just offset declines in per capita consumption of fresh. Since 1965, per capita consumption increases of processed potatoes have more than compensated for the decline of fresh consumption, yielding a steady increase in total per capita consumption. Much of this increase can be attributed to the growing consumption of frozen potato products, primarily frozen french fries. Whereas per capita consumption of frozen potatoes amounted to 14.3 pounds in 1965, this total had increased to approximately 40 pounds in 1980. Frozen french fries comprised 83 percent, roughly 33 pounds, of this 1980 frozen potato consumption.

It should be emphasized that some growth of the potato industry occurred even during the 1950-65 period when increases in per capita consumption of processed potatoes were virtually offset by declines in per capita consumption of fresh. Growth occurred as total quantities consumed increased with population growth. Continued population growth coupled with more than offsetting quantities going into processed potatoes since 1965 has accelerated the rate of growth of the industry.

Structural Attributes Within the Potato Market

Structural attributes are those forces or conditions either inside or outside a market which influence the behavior of firms and ultimately market performance. Since demand and supply are the crucial elements of a market, structural attributes of significance must influence these elements (Cochrane, 1957). This section will focus on those attributes within the processed potato market that are influencing or can influence the performance of the potato industry.

A comprehensive list of structural attributes relevant to agricultural commodities has been provided by Cochrane (1957). Other authors, Bain (1942), Lanzillotti (1960), and Clodius and Mueller (1961), have also provided fairly comprehensive discussions of structural attributes. This discussion, however, follows Cochrane most closely. According to Cochrane, seven structural attributes are pertinent to agricultural markets: (1) number of operators, (2) product homogeneity or product differentiation, (3) product durability, (4) bulkiness of product in relation to its value, (5) ratio of overhead costs to variable costs, (6) continuity and length of the production process, and (7) adequacy of grade description for buying and selling. Each of these attributes will be considered for its relevance to the potato industry.

Cochrane (1957) argues that the fewer the number of operators, the greater the likelihood of market collusion. Firms recognize that one firm could reduce its price and affect the sales of others. Consequently, recognizing their interdependence, they are likely to collude (either formally or tacitly) on price and the probability of this collusion increases as the number of operators decreases. Bain (1942) and Lanzillotti (1960) argue that other factors such as the number and degree of concentration among buyers and the size distribution of firms in relation to number are also significant in determining the likelihood of market collusion. Clodius and Mueller (1961) emphasize that the interdependence of structural attributes cannot be considered independently. They argue that firms, when few in numbers, are likely to differentiate their product and use non-price competition instead of price collusion.

As suggestive of market influence, the number of operators in the potato industry has declined continually since the 1960's. This loss of operators is reflected in the loss of operating plants, although there may not be a one-to-one correspondence. The number of potato chip plants has declined from 400 in 1960 to roughly 177 in 1980.

Frozen plants declined from 97 in 1964 to only 19 in 1980, a decrease of 80 percent. Reversing this trend is the number of dehydrated plants; available statistics show an increase from 28 in 1964 to 33 in 1980. This increase probably has resulted from the entry of potato chip and frozen processors into potato dehydration as they recognized the feasibility of processing dehydrated products from potatoes otherwise unsuitable for chips or frozen products.

Reductions in the number of plants and operators are believed to have influenced market power within the industry. Frito-Lay, the largest processor of potato chips, reportedly increased its market share from 20.9 percent in 1970 to 31 percent in 1982 (Warwick, 1971; Snack Food, 1982). Wise, the second largest processor of potato chips, purchased several smaller chip processors in 1980 and these acquisitions are expected to increase its market share. While the national market share of Wise is not known, it supposedly controls more than 50 percent of the market in the New York metropolitan area, and a larger market share than Frito-Lay all along the east coast (Warwick, 1971; Snack Food, 1982). The frozen potato market is equally if not more concentrated than the chipping market. One firm alone, Ore-Ida, currently controls 54 percent of the retail market for frozen potatoes. (Quick Frozen Foods, May 1982). And although the retail market represents only 24 percent of the total market for frozen potatoes, this same firm is a major supplier to the institutional market. The number one and three frozen potato processors, J.R. Simplot and Lamb-Weston respectively, control a major share of the institutional market.

As suggested in the theoretical framework developed by Clodius and Mueller, potato processors, recognizing their numbers and market shares, have ostensibly resorted to product differentiation as a means of increasing their sales and profits. This product differentiation undoubtedly has, in effect, become a form of conduct to further reduce the number of operators. Because there is limited buyer concentration in the retail market, consumers apparently have little countervailing power. While the number of potato processors may be relatively large, it seems that their size distribution may be the most important determinant of their conduct and performance (Lanzillotti,1960).

Product differentiation in the processed potato industry could have changed the type of competition from price to non-price and greatly augmented the intensity of this non-price competition. This would be consistent with the theoretical argument advanced by Cochrane. The expansion of Ore-Ida in the retail frozen potato market is an excellent example of this non-price competition. Ore-Ida accounted for 28 percent of retail potato sales in 1967-68; by 1981 this share had increased to 54 percent as the company introduced many new products and greatly expanded its advertising expenditures on existing products.

Although product differentiation undoubtedly has enhanced the degree of non-price competition in the processed potato industry, its traditional role has been one of maintaining excess profits in industries through its ability to act as an effective entry barrier. Consumers develop preferences for particular brands and continue their consumption of these brands even when other lower priced brands of similar quality are available (Comanor and Wilson, 1967). Nonprice competition, of course, is a method firms frequently use to maintain this consumer loyalty.

Cochrane (1957) argues that the elasticity of supply of an agricultural commodity is influenced by its durability . Of all vegetables, potatoes are probably the most durable. Fall potatoes, for example, can be stored from eight to ten months. This quality of potatoes should have enhanced revenues for raw potato producers and contributed to more efficient production scheduling for processors. Frozen potato processors, because of their large size and long operating periods, probably benefit the most from the storability of raw potatoes. Processors of dehydrated potatoes should also benefit from the durability of fresh potatoes but to a lesser extent than frozen processors because of shorter production periods. Potato chip processors, being generally small with limited production periods, probably receive the least benefit from the storability of potatoes.

The durability of the final products produced by processors influences the elasticity of supply for these products and ultimately processors' performance. Dehydrated products have an almost unlimited shelf life. Frozen potatoes also have an extended life but storage cost is a more significant factor than for dehydrated products. Potato chips have a limited shelf life and receive excessive breakage from handling and transporting. These product characteristics should yield a rather elastic supply response for dehydrated potatoes and somewhat less elastic responses for frozen potatoes and chips.

The weight of fresh potatoes in relation to their value has had a major influence on the current structure of the processed potato industry. Because of the weight-losing properties of potatoes, processors of frozen and dehydrated potatoes have located their plants proximate to major production areas. This minimizes transportation cost as processed products have higher value/weight ratios. Increasing these value/weight ratios expands the geographic area over which these products will be utilized, influences the number of processors and ultimately influences the elasticity of demand facing processors (Cochrane, 1957).

Potato chip processors have received limited if any benefits from the weight-losing properties of potatoes. This results because minimum product distribution costs for potato chips occur from plant location near large population centers as opposed to major potato producing areas. Plant location near producing areas would result in excessive product breakage as chips are transported to consuming areas. And even if chips did not experience breakage in transport, their bulkiness relative to value would still make plant location near production areas nonoptimum unless these areas corresponded to large population centers.

According to Cochrane, the ratio of fixed to variable costs is a net determinant of supply response as well as the slope and position of an industry's supply curve. This ratio, although currently unknown, is hypothesized to be increasing for the processed potato industry. This hypothesis arises from the rate of exit of smaller firms from the industry. Larger firms, having accelerated their rate of adoption of new processing technology, may have raised the minimum efficient plant size beyond that attainable by smaller firms.

The length of the production period in the processed potato industry is directly proportional to firm size. Larger firms operate more hours per day and more days per year than other firms in the industry. The supply curve for processed potato products is therefore more elastic as a result of larger firms extended production periods (Cochrane, 1957). It is of interest to note that larger potato processers generally face a constant long run supply price for raw potatoes. Per unit variable cost remains fairly constant as production increases because larger processors purchase a major proportion of their raw potatoes through contracts at fixed unit cost. Long-run supply price increases significantly only when processors underestimate requisite quantities and have to make sizable purchases on the open market at higher than contract prices.

Of the seven major structural attributes discussed by Cochrane, perhaps none is more applicable for the processed potato industry than the adequacy of grading. Each processed potato product, with slight exceptions for some dehydrated products, is best produced from a specific grade and quality of potato. Contract purchases have arisen partly as a result of processors' need for specific quality characteristics in their potatoes. Once the processed products are produced, grading ceases to be an important structural attribute as grading becomes standardized and consumers make purchases by package size.

Structural Attributes Outside the Potato Market

Several forces external to the potato industry have had and continue to have significant effects on the industry. Uncertainty exists as to whether these forces are pulling the industry, internal forces are pushing the industry, or both sets of forces are interacting to propel the industry forward. This section will provide a brief discussion of the following external forces which appear to be significant in altering the structure of the potato industry: (1) changing consumers' tastes, (2) growing percentage of women in the labor force, (3) increasing population, (4) rising income, and (5) increasing away-from-home food consumption.

Changing consumers' taste is believed to have played a role in shifting potato consumption from its fresh to processed form. Quantitative measurements of taste being next to impossible, only qualitative discussions are most often provided. Observations on potato consumption seem suggestive of changing consumers' taste. Per capita consumption of fresh potatoes in 1910 amounted to 198 pounds; it declined to 100 pounds by 1950, and to 56 pounds by 1980. Consumption of processed potato products, however, increased from an unmeasurable amount in 1910 to 6 pounds per capita in 1950, and then to 62 pounds in 1980.

These changing consumption patterns are not in themselves indications of changing demand as supply also could have changed. Previous studies though suggest that there have indeed been changes in demand. Scott and Mumford (1949) attribute these changes to (1) a rising standard of living associated with increasing incomes, (2) increased availability of other vegetables and a desire for variety in the diet, (3) a lesser need for high-calorie foods in present day occupations, and (4) progressive urbanization of the U.S. population. Gray, Sorenson, and Cochrane (1954) ascribe these consumption changes to (1) declining immigration of people accustomed to heavy potato consumption, (2) the flight from calories explanation, and (3) variations of a civilization argument which suggests that modern housekeppers prefer convenience foods requiring little preparations, and modern housewives with outside jobs have little time for meal preparation.

Because much time has elapsed since the above studies, Hee (1967) suggests that the enumerated factors are less applicable for the period since the early 1960's. Two additional factors, in his opinion, have had a more pronounced effect: (1) the discovery and dissemination of factual information on the nutritional value of potatoes, and (2) the rapid introduction of processed potatoes. These two factors along with those enumerated by the other authors would probably prove significant in explaining changing potato consumption especially before the decade of the 1970's. Since 1970, four factors enumerated in the first paragraph of this section--growth of women in work force, population, income, and away-from-home food consumption--probably would provide more insight into changing potato consumption.

The growing percentage of women in the work force has served to alter considerably the market basket of goods consumed by households. Market baskets contain more convenience foods as households have less time to devote to meal preparation. Since potato processors presently perform many of the services traditionally performed by women, one would hypothesize a relationship between consumption of processed potatoes and women in the labor force. Available data support a direct relationship. From 1950 to 1980, women in the work force increased from 29.6 percent to 42.4 percent; consumption of processed potatoes increased during this period from 6 percent of all potatoes consumed to 61 percent. While not all this increase has been due to women in the labor force, recent studies suggest that they have accounted for a significant proportion of it (Beilock, 1981; Cardwell and Davis, 1980; Estes, 1979).

Population growth could have an impact on the potato industry simply by providing an expanding market. During the 1950-65 period, this factor seems primarily responsible for increased potato consumption as per capita consumption remained relatively constant. Many potato processors are expecting population growth to provide a continued source of industry expansion as they focus their advertising messages on attracting new users of their products. Available 1981 statistics suggest that 40 percent of American households are nonusers of the major processed potato product, frozen potatoes. If comparable rates exist for other products, current nonusers together with prospective users from population growth could represent significant growth potential for the processed potato industry.

The effect of rising income on potato consumption has not been clearly established. A study conducted by the U.S. Department of Agriculture (1955) found a positive relationship between potato consumption and rising income for low-income households, but a negative relationship for high-income households. Shuffett (1954) found an income elasticity of demand for potatoes of .42. Most studies, however, have found a very weak or no income effect. These relationships have been established primarily for fresh potatoes as the studies were conducted before the introduction of the many processed forms. In a more recent study, Estes (1979) found an income elasticity of demand for processed and fresh potatoes of .67 and .11 respectively. With processed potatoes becoming an increasing proportion of total consumption, rising incomes could have greater significance for the potato industry.

A close parallel to the income elasticity of demand for potatoes is the income elasticity of demand for away-from-home food consumption. Of particular significance to the potato industry is the rate of increase of food consumption at fast food establishments. Consumption of processed potato products, particularly frozen french fries, is believed to be far more prevalent at fast food than non-fast food establishments. Available statistics indicate that changes in food consumption at fast food establishments have greatly outpaced that of non-fast food establishments. Food consumption at fast food establishments increased between 1972 and 1977 at an annual rate of 10.3 percent as compared to 1.9 percent for non-fast food establishments (Table 1.4). Fast food expenditures in constant 1967 dollars have increased from $1.1 billion in 1958 to $10.4 billion in 1977, an increase of over 800 percent. By way of comparison, non-fast food expenditures increased during this

Table 1.4--U.S. Away-From-Home Food Expenditures (millions of 1967 constant dollars)

	Fast Food Establishments	Annual Percent Change	Non-Fast Food Establishments	Annual Percent Change
1982	$11,803		$19,476	
		2.6		2.5
1977	10,443		17,305	
		10.3		1.9
1972	6,890		15,819	
		18.9		1.0
1967	3,538		15,051	
		24.0		2.7
1958	1,120		12,118	

Sources: U.S. Census of Business , 1958-1982.

period from $12.1 billion to $17.3 billion, an increase of 43 percent.

Concept of Performance

Market structures within the U.S. are quite diverse, ranging from near monopoly to almost pure competition. Within these structures, there are recognized levels of performance. However, little knowledge exists as to how various structures impact performance and, in turn, are impacted by performance. Similarly, disagreement exists on the recognition and measurement of performance. As used in this study, performance relates to (1) stability of margins; (2) profitability of production, (3) progressiveness of the industry, and (4) growth of production. Applying these concepts to the potato industry requires the articulation of quantitative measurement techniques.

Criteria for Analyzing Performance

In addition to the aforementioned performance measures, other measures for evaluating performance also have been proposed. Some of these include (1) differences of capacity utilization from available capacity, (2) percentage of total market held by top 4, 8, or 10 firms, and (3) rate of change of expenditures on advertising and research and development. While each of these measures will be an integral part of the specified econometric model, they will be used only in conjunction with the previously specified performance concepts to evaluate the overall performance of the potato industry.

Stability of margins as a performance measure may appear counter to the ostensible profit maximization objective of firms, but its use here is intended to measure the extent in which larger firms pass on cost advantages in the form of lower prices and subsequent increased output (Collins and Preston, 1969). High variability in price-cost margins would suggest abnormally high prices during periods of industry adjustments. Stability of margins, on the other hand, would suggest profits, but the absence of supernormal profits. Thus, the variability of margins is one measure by which performance of the potato industry will be evaluated.

Although a positive price-cost margin would indicate profitability, an issue of concern here is the extent to which profits have been enhanced by the structure of the industry. With a few large processors controlling large percentages of the market for all processed forms of potatoes, it may be hypothesized that these processors' market power would lead to some discrepancy between price and cost. It may also be hypothesized that concentration among institutional food establishments provides some countervailing power for those products which are marketed primarily through institutional establishments. Price, according to general economic theory, would be determined in accordance with the relative bargaining strength of respective parties in the absence of collusion. If, as a minimum, tacit collusion exists between processors and institutional buyers, consumers most likely would be subjected to higher prices than those which would prevail under countervailing bargaining. Lacking information on the bargaining power of respective parties, the influence of concentration on margins will be used as a measure of the extent to which market power has enhanced profits.

A progressive industry may be defined as one which not only meets the demands of consumers but also influences or shapes these demands. An industry may use such methods as product development, pricing techniques, advertising, and product promotion. As quantitative data on many of these efforts are not available, advertising expenditures will be used here to evaluate the progressiveness of the potato industry.

Analyzing growth as a performance measure probably will require some relative comparisons of the potato industry with other industries. An alternative method would simply measure the growth of the industry in terms of its provision of the products demanded by consumers, that is, product availability. If the industry has made available many products with efficient allocation with respect to time, place and form, then the growth rate achieved should closely parallel optimum growth.

General Performance of Potato Industry

Potato production in the U.S. has increased considerably during the past three decades--rising from

259.1 mil. cwt in 1950 to 325.7 mil. cwt in 1970, and then falling to 302.8 mil. cwt in 1980. This increased production has come primarily from tremendous increases in yields per acre; total acreage in production has actually declined from 1,679.9 thousand acres in 1950 to 1,154.5 thousand acres in 1980, a decrease of 32 percent. Utilization of this potato production changed considerably during the 1950-80 period. Whereas nearly all potatoes were consumed in their fresh form in 1950, less than four-tenths were so consumed in 1980. This shifting of consumption has greatly altered the structure of the potato industry.

Per capita consumption of fresh potatoes has declined continually since 1950. Despite this continual decline, the rise in consumption of processed potatoes since 1965 has led to an overall increase in per capita consumption of total potatoes. Besides the per capita consumption decline of fresh potatoes, there also has been a decline in absolute consumption, a decline from 242.8 mil. cwt in 1950 to a 1980 level of 97.2 mil. cwt. The consumption of processed potatoes increased during this period from 16.3 mil. cwt to 152.9 mil. cwt.

Potato chips were the dominant processed potato product consumed until 1965. Since 1965, the volume of potatoes processed into frozen potato products as well as the per capita consumption of frozen potatoes has greatly exceeded that of chips. Reflecting back it may be recalled that 1965 was approximately the time that total per capita consumption of potatoes began to reverse its declining trend. Thus, despite the high utilization of potatoes in chips for earlier periods, it should be clear that rising consumption of frozen potatoes has played a significant role in generating the growth needed to reverse diminishing per capita consumption of potatoes.

Next to frozen french fries and potato chips, dehydrated potatoes (largely flakes and granules) constitute the third largest component of processed potatoes. In fact, these three components have consistently comprised from 75 to 87 percent of all processed potatoes. While the quantity of fresh potatoes channeled into dehydrated potato products has risen considerably during the past three decades, dehydrated products as a percentage of all processed potatoes have shown no consistent pattern of change. Dehydrated products rose from an unmeasurable amount of all processed potatoes in 1950 to 17.1 percent in 1960, to a high of 23.1 percent in 1976, and then declined to 18.4 percent in 1980. Since 1965, per capita consumption of dehydrated products has increased from 7.0 pounds in 1965 to a high of 14.5 pounds in 1974, declined to 10.1 pounds in 1976, and then rose to 11.5 pounds in 1980.

Canned potatoes have always represented a small percentage of processed potatoes. Total and per capita consumption rose continually, although minimally, from 1950 to 1974. Since 1974, per capita and total consumption have remained relatively constant. Starch and flour, the other processed potato products, are no longer significant processed potato products. The amount of potatoes used in the production of starch and flour has declined from a high of 20 million cwt in 1961 to a 1980 level of 2 million cwt, a decline of 90 percent. These changes suggest that starch and flour are residual products with production highly dependent on prices. This relationship has been partly confirmed by Hee (1967) as he found the elasticity of demand for potatoes used in starch to be 1.01. This elasticity estimate suggests that starch producing plants are operated below capacity during periods of low production and relatively high potato prices, but these plants approach normal capacity as production increases and prices fall.

Despite fluctuations in the patterns of consumption of some processed forms of potatoes, continual increases in the consumption of frozen potatoes have served to greatly expand the growth rate of processed potatoes relative to that of seven major processed vegetables (Figures 1.1 and 1.2). These vegetables are asparagus, cabbage, cucumbers, snap beans, spinach, sweet corn, and tomatoes. Although the percentage of these vegetables going into processing has always exceeded that of potatoes, processed potatoes as a percentage of all potatoes are continually increasing. The processed percentage of the seven major processed vegetables, on the other hand, is decreasing. Stated differently, processed potatoes seem to be more readily

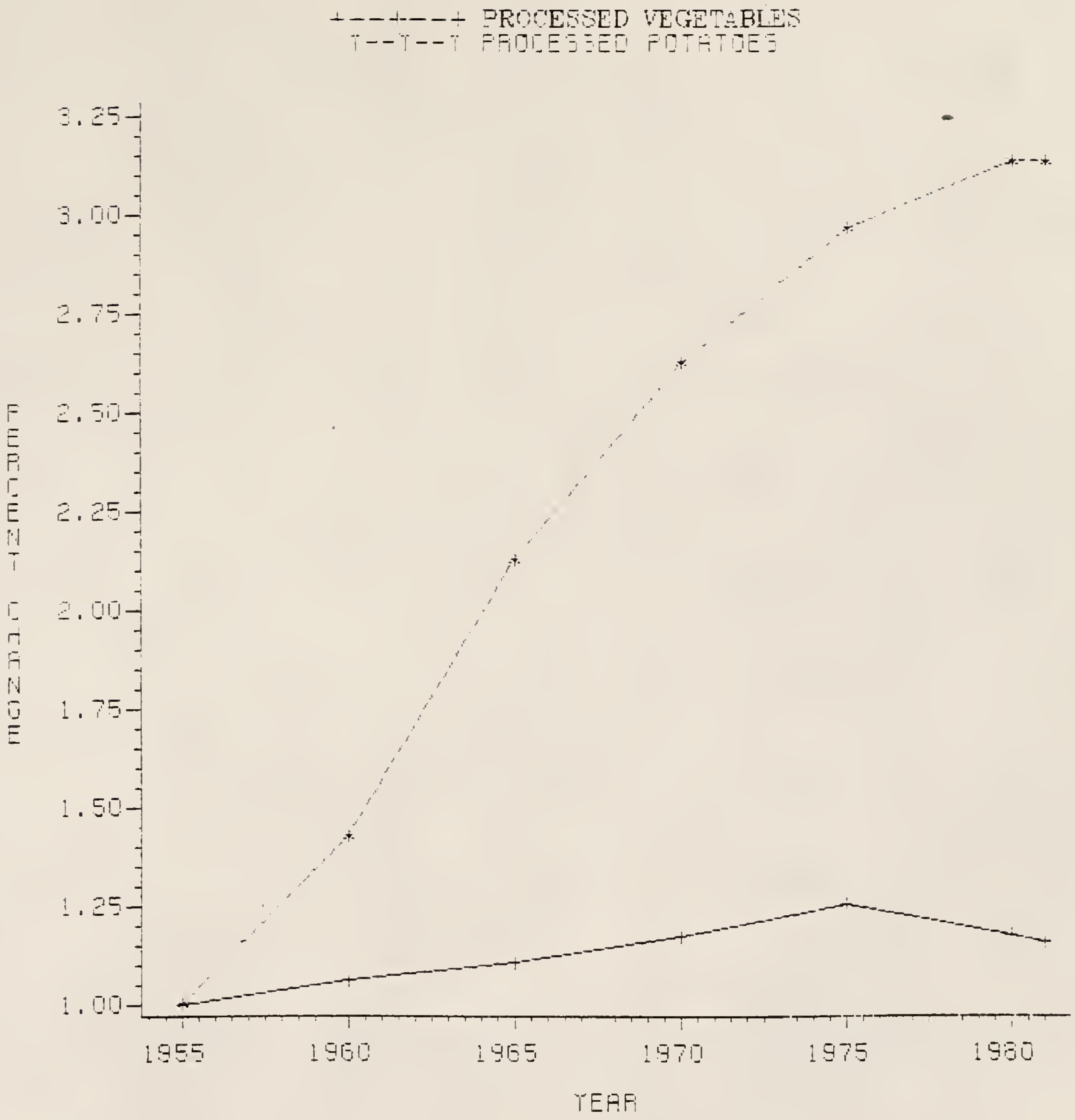


Figure 1.1. Percent Changes in Consumption of Processed Vegetables with Comparison to Potatoes

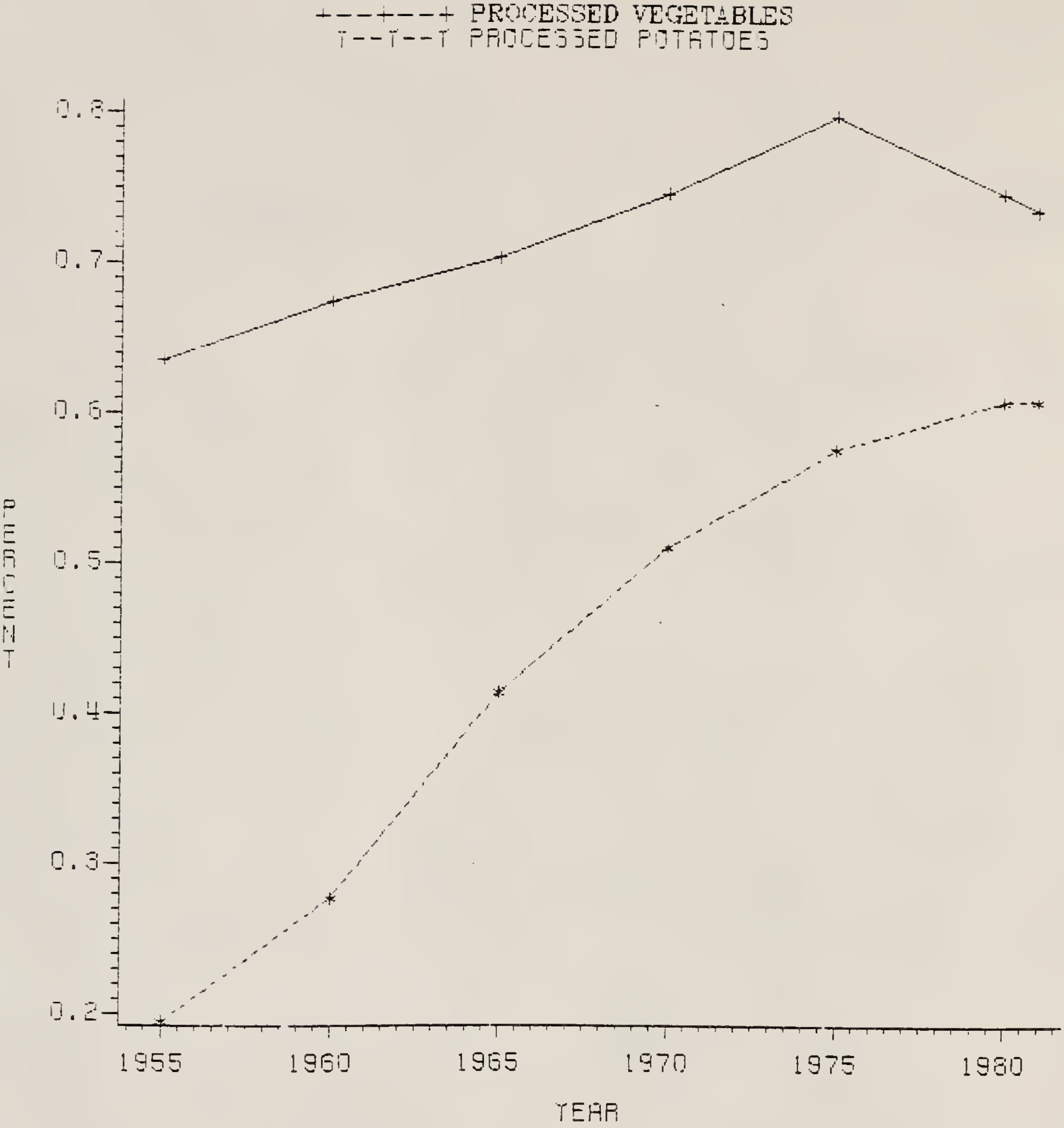


Figure 1.2. Changes in Consumption of Seven Major Processed Vegetables with Comparison to Potatoes

meeting the demands for convenience foods than other processed vegetables.

Relative gains of processed potatoes on other vegetables have resulted largely from the gains frozen potatoes have made on other frozen vegetables (Figure 1.3). Leading the growth of frozen potatoes are frozen french fries. Presently, frozen fries account for 82 percent of all frozen potato products; they account for 53 percent of all frozen vegetables; and they are consumed at more than twice the rate of the seven leading frozen vegetables. These vegetables are broccoli, carrots, corn-on-cob, cut corn, green beans, green peas, and spinach. Frozen french fries in 1980 constituted 30 percent of all frozen retail vegetables and 65 percent of all institutional vegetables. Commercial development of frozen french fries began in 1947, and as the preceding discussion suggests, they have since shown remarkable growth.

Problem Statement

Structural changes in the U.S. economy since the early 1950's together with some specific to the potato industry have had and continue to have significant impacts on the potato industry. Changes include (a) an increasing demand for away-from-home food consumption, (b) a changing labor force composition, (c) a rapidly expanding fast food industry, (d) a rising per capita income, (e) a reduction in household size, but an increase in number, (f) a growth of population, and (g) a change in consumers' taste.

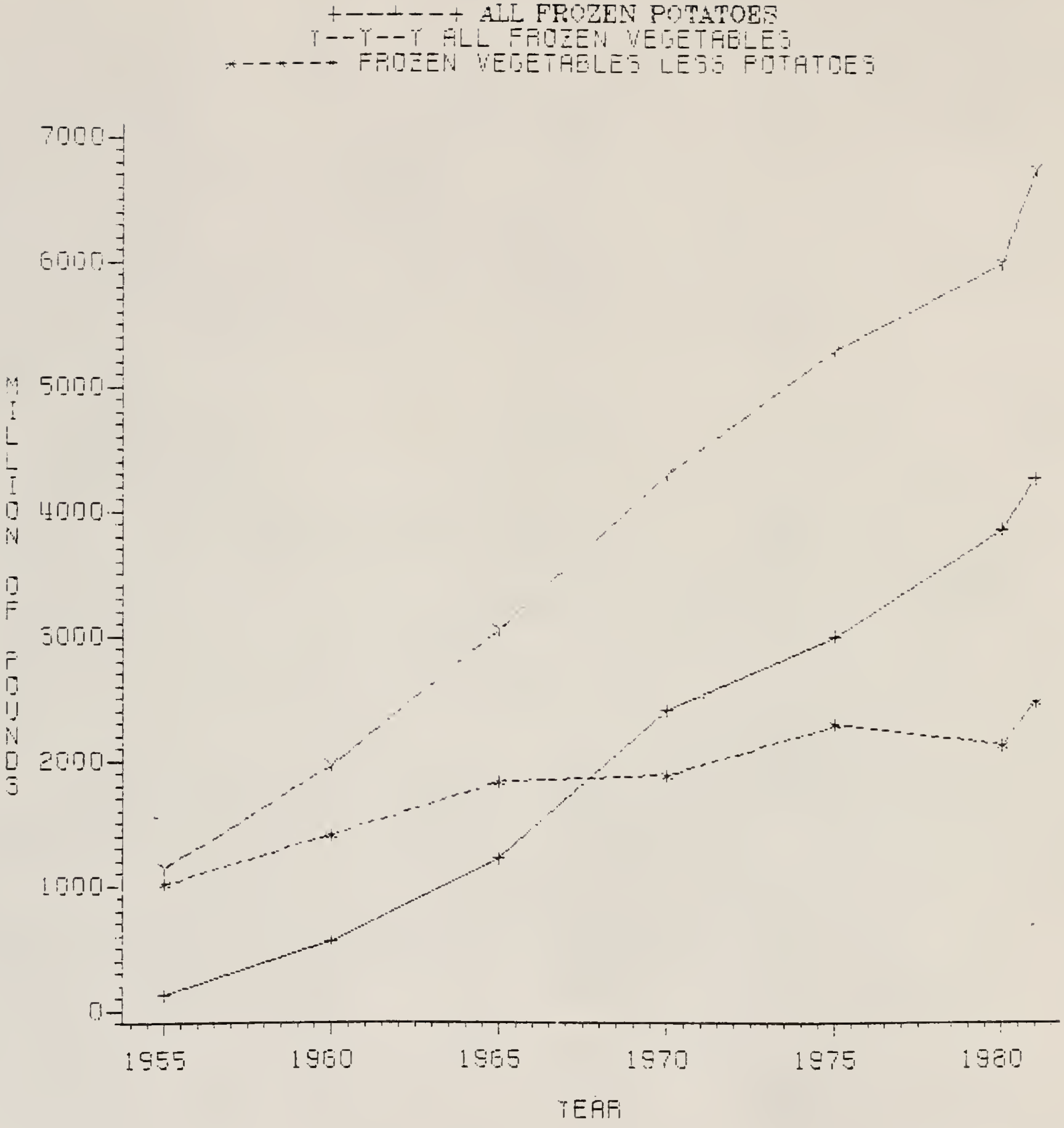


Figure 1.3. Consumption of Frozen Vegetables with Comparison to Potatoes

Changes specific to the potato industry are (a) a falling demand for fresh potatoes, (b) a rising demand for processed potatoes, and (c) a spatial redistribution of production, both raw and processed forms. As a result of these changes, there have been (a) a significant shift in the utilization of potatoes from their fresh to processed forms, (b) a rapid development of processed potato products, (c) a decrease in the number of potato processors, but an increase in their size, (d) a significant increase in advertising expenditures for processed potato products, and (e) an expanding expenditure of funds for potato research and development.

Although the above changes are well recognized, little knowledge exists as to how these external and internal forces have interacted to affect the structure and performance of the potato industry. Changes external to the industry could have precipitated as well as continued the changing structure of the industry. Under this scenario, the industry should stabilize when these forces stabilize. Alternatively, if forces internal to the industry have been the primary determinants of change, then the long-run stability of the industry becomes dependent upon the extent to which these forces continue their pattern of change.

Structural changes, although important, are secondary to identifying and determining the performance of an industry. Performance generally will have some influence on the ultimate structure of an industry. For the potato industry, performance is important as it relates to three separate but not necessarily distinct groups. These groups consist of (1) raw potato producers, (2) consumers and, (3) potato processors.

Raw potato producers, having an increasing percentage of their potatoes purchased through contracts, are less dependent on the direct operation of the forces of demand and supply in determining prices and revenue. Theoretically, contract purchases should have reduced price risk to growers and, under certain conditions, increased their creditworthiness as these contracts may be used as a form of collateral in securing business loans. This reduced risk and increased creditworthiness could come at the expense of total revenue. Such trade-offs must be analyzed from the perspective of the overall performance of the industry.

Changes in the potato industry have provided consumers with more and a greater variety of products from which to choose. Some economists would argue that this has to represent an increase in welfare because more is better. However, if we equate consumer welfare with consumer surplus, it may be shown that more and a greater variety of products are not equivalent to a gain of welfare for consumers when these products are supplied at prices in excess of their costs. Consequently, analysis of price-cost margins is one standard by which performances of the potato industry will be measured.

Potato processors, like raw potato producers, should have experienced some reduction in risk from contract purchases as this method of acquisition assures available supplies for more efficient production scheduling. Such risk, and therefore cost, reduction could be reflected in prices paid for raw potatoes, prices paid by consumers for processed products, processors' profits, or some combination of these elements. Evaluating the impacts of contract purchases on various industry participants may be best performed by determining the distribution of income resulting from the changing structure and performance of the potato industry.

In summary, the problems involve the determination of those factors which have caused the transformation of the potato industry, and then measuring the impacts of these factors with respect to time. For example, it may be hypothesized that variables relating directly to demand and supply will have a more immediate effect on the industry than those relating to structure and performance. Thus, an intriguing aspect of this study will involve separating out the time dimension of the impacts of both endogenous and exogenous factors. A related problem involves the determination of the future of the industry. This problem will be addressed by deriving the reduced form of the model and then shocking the system to determine the impacts of these shocks.

Hypotheses

1. Because of structural changes external to the potato industry, the industry has evolved from an elementary structure with nearly all potatoes being consumed in their raw form to a very complex structure with processed products dominating consumption.

2. Expenditures on research and development by large potato processors have led to the discovery and adoption of new processing technology. This technology has raised the minimum efficient plant size beyond that attainable by most small firms, thereby causing their exit from the industry.

3. The potato industry, recognizing and responding to demands emanating from external changes, has undergone significant internal changes in accommodating these demands. These internal changes have altered the structure and performance of the industry; continued interaction of structure and performance should serve to further shape the industry.

4. The changing structure and performance of the potato industry have altered the distribution of income accruing to various participants within the industry.

5. Determining the direction and extent of future external change should allow for the simultaneous determination of the future structure and performance of the potato industry.

Objectives

Many factors have contributed to the changing structure and performance of the potato industry during the past three decades. The primary objective of this study is to identify these factors and evaluate their relative impacts. A corollary of this objective, of course, is to evaluate the impacts of industry changes on consumers and various participants within the industry.

Specific objectives necessary to the accomplishment of the primary objectives are

1. Development of a theoretical model which illustrates how the potato industry could be affected by various exogenous and endogenous factors.

2. Development of the empirical counterpart to the model in (1) which quantifies the effects of both exogenous and endogenous factors.

3. Interpretation of the empirical results in terms of the impacts industry changes have had on consumers and industry participants.

4. Evaluation of the ultimate performance of the industry in light of the developed theoretical model.

Methodology and Scope

Sixteen endogenous and twenty exogenous variable are identified to explain the changing structure and performance of the potato industry. These variables are incorporated into an econometric model which allows for a simultaneous, two-way relationship between the structure and performance variables. For example, the structure variable concentration may influence the performance variable profitability while profitability simultaneously influences concentration as well as other structural variables.

This study encompasses all raw potatoes and all processed forms. Processed forms have been grouped together for estimation purposes. For example, no attempt will be made to estimate the degree of concentration in the chipping industry separate from that in the frozen potato industry. Aggregation of data is not expected to distort the results as all product forms generally have exemplified the same trends in terms of such factors as concentration, firm size, number of firms, and advertising expenditures.

Once the econometric model has been estimated, various simulations will be performed to illustrate the industry response to certain economic shocks, whether endogenous or exogenous. Also, the model will be used to provide projections of changes over time. One area of particular interest is to simulate the industry response to continued food consumption away-from-home.

Subsequent Chapters

A review of literature applicable to the potato industry is provided in Chapter II. This review is followed by a brief overview of the potato industry in Chapter III. A theoretical model, delineating the exogenous and endogenous variables which most likely impact the industry, is developed and presented in Chapter IV. An econometric model is developed and estimated in Chapter V. A discussion of the econometric techniques and problems associated with the model is also provided in this chapter. The econometric results are discussed in Chapter VI in light of the theoretical model developed in Chapter IV. A discussion of the uses for this type of simultaneous equation system is provided in Chapter VII. The study concludes with a discussion of policy implications in Chapter VIII.

CHAPTER II
LITERATURE REVIEW

Introduction

This chapter will provide a discussion of previous studies of the potato industry for the purposes of (1) shedding insights on the approaches and results of other authors and (2) providing a foundation for evaluating the contribution of the present study. Because of its high value as a farm commodity, many theoretical and empirical analyses have been completed on potatoes. This review, however, will be limited to econometric studies that contain at least an empirical content on potatoes.

Previous Studies

The econometric studies discussed here may be grouped into three categories: (1) comprehensive, (2) moderately comprehensive and (3) least comprehensive. Studies in the last category are so classified as they pertain to potatoes; these studies typically addressed several agricultural commodities but with no indepth analyses of any. Comprehensive studies include the work of Zusman (1962), Hee (1967), Estes (1979), Cardwell and Davis (1980) and Beilock (1981). Studies by Gray, Sorenson and Cochrane (1954) and Simmons (1962), while classified as moderately comprehensive, are actually comprehensive in their theoretical analyses, but less comprehensive in their empirical or econometric analyses. The studies of Fox (1953), Shuffett (1954) and Waugh (1964) estimated the demand and price structure for several commodities but with no specific focus on potatoes. A discussion of these ten studies in the reverse order of their classification follows.

Least Comprehensive Studies

Fox (1953) estimated demand equations for several agricultural commodities using single-equation least-squares estimation. He suggested that this procedures was most appropriate for potatoes, since the price for any given year was not materially affected by production, consumer income, or supplies of competing products. Estimates for the farm demand equation with price as the independent variable showed a highly inelastic demand with respect to price but a less inelastic demand wth respect to income. Specifically, price flexibility coefficients of -3.51 and 1.20 were found with respect to production and income, respectively. In addition, the author concluded that elasticities of demand for potatoes at the farm and retail levels were probably equal. He also found that 98 percent of the variation in farm prices of potatoes was explained by changes in retail prices.

Shuffett (1954) was the first to estimate seasonal demands for potatoes. The total U.S. potato crop was divided into early potatoes, production from December through August, and late potatoes, production during the remaining months. Early potatoes comprised an average of only 18 percent of production for the 1920-41 study period; late potatoes represented the remaining 82 percent. The motivation for separating production stemmed from the nature of the product. Early potatoes are more perishable and must be moved through the market upon harvest. Late potatoes, on the other hand, can be stored and therefore marketed more orderly.

Using the single-equation approach as justified by his predecessor, Shuffett found the demand for early potatoes to be inelastic but less inelastic than that for late potatoes. The cross elasticity for early potatoes was found to be less than the direct-price elasticity assuming, of course, that elasticities are derivable as reciprocals of price flexibility coefficients. This suggested that while late potatoes do compete with early potatoes, they are less than perfect substitutes. The income flexibility coefficients suggested a higher income elasticity for early than late potatoes. Also, like his predecessor, Shuffett concluded from his attempts to calculate price elasticity of demand at the retail level that it was probably equal to its farm level value. A higher retail than farm level elasticity was actually derived, -.40 versus -.25, but Shuffett concluded that these were essentially equal because not all quantity produced moved through retail channels.

Unlike his predecessors, Waugh (1964) found what he considered to be considerable differences between price elasticities at the farm and retail level. In fact, determining differences in elasticities for farm commodities at the farm and retail levels were the primary focus of his study. Using a 1948-62 data period, he found that a 1 percent increase in consumption resulted from a 5.3 percent decrease in price at the farm level but only a 2.6 percent decrease at the retail level. It should be emphasized though that his farm level demand was a derived demand. Waugh estimated demand at the retail and wholesale levels and then estimated farm demand as the difference of these demands. Income was found to have a positive effect on retail price but an unexpected negative effect on farm price.

To recapitulate, all authors used the single equation approach to estimate the price and demand structure for potatoes. Waugh (1964) concluded from his findings that demand was far more elastic at the retail than farm level. Fox (1953) and Shuffett (1954), on the other hand, concluded that elasticities at the two levels were probably equal. In their opinions, an appearance of a higher elasticity at the retail level resulted because the quantity used to derive this measure understated actual quantity. In estimating seasonal demands for potatoes, Shuffett (1954) found some substitutability between early and late potatoes, but a higher preference for early than for late potatoes.

Positive income elasticities were found for all estimated demand equations, though for a derived farm level demand equation, Waugh found a negative income elasticity.

Moderately Comprehensive Studies

Gray, Sorenson, and Cochrane (1954) developed primarily a theoretical analysis which addressed the problems of price and income instability for potato farmers. These problems, in the authors' opinions, resulted from demand inelasticity for potatoes and price expectations of potato farmers (p. 172). That is, an expected high price led to a large production which, in turn, led to low prices and income because of the inelastic demand for potatoes. Though the authors recognized that many exogenous factors had impacted the potato industry, they suggested that these had not been the major cause of price and income instability. Even if these exogenous forces continued, the authors suggested that income and price stability could be obtained through either controlling production or influencing the elasticity of demand. Production or supplies could be controlled, for example, through acreage allotment or marketing orders. A more elastic demand could be obtained through various price support programs. The authors discussed the merits of these stability programs after empirically deriving the demand and price structure for potatoes.

Unlike their predecessors, the authors did not include income as a relevant explanatory variable. The farm price of potatoes was estimated as a function of consumption and a trend variable. The estimates revealed that farm price decreased by 2.7 percent for each 1 percent increase in consumption. The trend variables revealed that, for the 1910-42 period, the declining per capita consumption of potatoes had not been completely offset by the growth of population. Estimates for a previous period, 1870-1909, showed that population growth had increased total potato consumption by three times the rate of increase in per capita consumption. With the population changing at similar rates over both data periods, the authors concluded that forces which could precipitate greater instability had been introduced during the latter period. To contain this instability, the authors developed several theoretical arguments which encompassed the aforementioned factors.

Simmons (1962) also developed a fairly comprehensive theoretical analysis of the potato industry. He stressed methods of ameliorating price and income instability for potato producers. For the 1950-61 period, he had observed a continuation of those instability measures noted by Gray, Sorenson and Cochrane (1954). Simmons emphasized a need for the government and the potato industry to superimpose additional demands upon the free market demand. One suggested method of imposing an industry demand was through product promotion, a measure eventually adopted in 1973. Controlling or influencing the elasticity of demand, in his opinion, would be more effective than supply management because much variation in supply is due to uncontrollable factors such as weather and pests.

While both Gray, Sorenson and Cochrane (1954) and Simmons (1962) recognized possible differentials in supply-price relationships by seasons and geographic areas, only Simmons attempted to capture them in his econometric estimates. He estimated four seasonal and three regional demand equations with price as the dependent variable. Supply equations corresponding to each demand equation were also estimated with acreage as the dependent variable. In addition, the author estimated intraregional demand and supply equations as well as total U.S. demand and supply. Supply was found to be inelastic at the national and regional levels.

Unlike Shuffett who estimated early and late seasonal demands, Simmons divided early potatoes into three groups: winter and early spring, late spring, and early summer. For the 1950-61 data period of this study, these three groups, in the order in which they are listed, represented respectively 3, 10 and 6 percent of total production. The remaining 81 percent for the late crop was essentially equal to its level for the 1920-41 period of the Shuffett study. The demand equation for winter and early spring potatoes revealed that late potatoes were very competitive with them; in fact, a 1 percent change in production of winter and early spring potatoes had a smaller effect on its own price than that of a 1 percent change in production of fall potatoes. These effects were reversed in the demand equation for late spring potatoes. Because of product perishability, late fall potatoes were not considered competitive with early summer potatoes. Late spring potatoes though were considered competitive with early summer potatoes and they were found to have an unexpected positive impact on them. However, because two of the three parameter estimates in this equation were nonsignificant, the authors concluded that the regression results were questionable.

Estimates for the late summer and fall crop revealed that a 1 percent change in its production resulted in a 5 percent decline of price in the opposite direction. A nearly identical price effect was found for total U.S. production, a result which may have been expected as the late summer and fall crop represented over 80 percent of production. Income was found to have negative but nonsignificant impacts on total as well as late summer and fall demands, a finding opposite that noted in previous studies. The -.21 price elasticity for total potatoes, however, was fairly consistent with that found by Shuffett (1954), Fox (1958) and later observed by Hee (1967).

Separate regional demand equations for the eastern, central and western regions revealed that only prices in the western region were materially influenced by production changes in competing regions. A 1 percent change in production in the eastern and central regions resulted in an opposite change in prices in the western region of 5 percent. The author concluded that prices in the western region were influenced by production in competing regions because a large proportion of its production was shipped out whereas the competing regions consumed most of their production. As in the seasonal demand equations, the author found nonsignificant income effects, though both positive and negative income parameters were observed.

Comprehensive Studies

Zusman (1962) developed and estimated an econometric model of the entire U.S. potato industry, even though he was primarily interested in California potato production as an element of total U.S. production. Specifically, he wanted to ascertain that level of production of California potatoes that would result in profit maximization for its growers. Because of the competitive nature of the industry, he noted that this could be obtained only by observing the interrelations of California potatoes with total U.S. production. To this end, he empirically estimated his econometric model with a view toward framing a policy for California production.

Zusman, like his predecessor Shuffett, divided the potato industry into two seasonal markets, though the markets encompassed dissimilar time periods. A spring market which encompassed all of California production and a winter market which encompassed the bulk of U.S. potato production were defined by Zusman. Three demand equations, three supply equations, three margins equations, three supply identities and one production carry-in equation were estimated primarily through a simultaneous equation approach. As only the acreage of potatoes was estimated and then multiplied times average yield to get total supplies, these results are not emphasized here. The supply of potatoes was found to be inelastic.

As with previous authors, the estimated results of Zusman showed a more elastic demand for the smaller spring crop than the larger winter crop. Moreover, separating the winter crop into food and nonfood uses, Zusman found a higher demand elasticity for the latter than for the former, a finding later confirmed by Hee (1967). A much lower elasticity of demand for potatoes was found by Zusman than that found by other authors (Hee 1967; Shuffett 1954; and Gray, Sorenson and Cochrane 1954). Zusman attributed these differences to the fact that his estimates were for potatoes used only as food whereas other authors included all potatoes. The demand equation for spring potatoes revealed that significant differences existed among California spring potatoes, other spring potatoes, and carry-in potatoes. The associated short and long run multipliers derived from these differences together with other multipliers provided the framework for Zusman's policy analyses on profit maximization for California producers. By varying California production through assumed collusive action of producers, the author determined the resulting profit for alternative production levels. In general, the results revealed that short-run gains in profit could be obtained, but only through increased market instability. Long run gains in profit were not obtainable.

By a similar seasonal division of the potato market as utilized by Simmons, Hee (1967) estimated the interrelationships among seasonal production. Potato production for one of the four seasons, summer and late fall, was not considered competitive with other seasonal production. Utilization of this fall crop, however, was considered competitive as alternative uses such as food, seed and feed competed for it. Nonfall potatoes, on the other hand, were hypothesized to be noncompetitive in utilization because they were used almost exclusively for food. Two-stage least squares as well as a limited information method were employed to estimate these relationships.

Separate demand equations for utilization of the late summer and fall crop revealed that distinct demands did exist for potatoes used for food, livestock feed and starch. As expected, the demand for food was more inelastic than for other uses. Disposable income was found to have virtually no effect on the demand for potatoes as food. Moreover, processed vegetables, believed to be a primary substitute for potatoes, were also found to have a nonsignificant effect on demand. No estimate of supply was obtained as it was assumed fixed for the late summer and fall crop.

Demand estimates for the remaining three equations, intended to reveal the degree of competition and substitutability between different seasonal potatoes, invariably showed higher direct than cross elasticities in absolute value. Even though positive and relative high cross elasticities were found, the estimates clearly revealed higher preferences for the dominant than competing crops. Storage potatoes from the late summer and fall crop served as the competing crop in the demand equations for winter and early spring as well as late spring potatoes. Early summer potatoes were found to be competitive with late spring and late summer potatoes.

The effect of income on demand was nonsignificant in all four equations, though a positive and high income elasticity was revealed for winter potatoes. Specifically, a 1 percent change in income generated a .3 percent change in demand for winter potatoes. It should be emphasized though that even the sign of this income parameter varied with the estimating technique. Logic then would suggest that income had a nonsignificant, if any, effect on demand. This pattern of relatively nonsignificant income effects has persisted for all the studies which to date have examined data periods from 1920 to 1960.

It may be noted that the three estimation techniques used by Hee generally yielded entirely different results. Though the author noted the appropriate uses for two-stage least squares, limited information maximum likelihood, and ordinary least squares, he emphasized the best results irrespective of which technique yielded them. Such varying emphases naturally compromised consistency.

Estes (1979) conducted a more comprehensive study of the potato industry than those discussed heretofore. While the primary goal of the study was to examine the impacts of changing potato production in the U.S. Pacific Northwestern region, the model developed to evaluate these impacts encompassed the entire industry. Unlike Gray, Sorenson and Cochrane (1954) who estimated potato acreage, Estes estimated acreage and yield and then derived production as the product of the two. These equations, estimated by ordinary least squares and a maximum likelihood technique, revealed that supply was generally price inelastic. Supply elasticities varied among six identified production regions. A variable included to capture risk, variance of potato prices, was found to have only a modest effect on planted acreage.

Demand equations were estimated for potatoes used as food, but for the first time these potatoes were separated into fresh and processed uses. An additional equation for potatoes used as livestock feed was also estimated. All of these equations were estimated at the national level. Retail level demand equations for potatoes as food were derived by using farm price together with price and cost indexes as proxies for margins. Demands were found to be less price inelastic for processed than for fresh potatoes

(-.235 versus -.124). Positive but nonsignificant income effects were found for both fresh and processed demand equations. These findings were consistent with those of previous studies.

To capture the effects of changes in demand for convenience foods, Estes included the percentage of women in the labor force in his fresh and processed demand equations. The estimated results showed a 1.1 percent decline in fresh potato demand but a 4.7 percent increase in processed potato demand for each 1 percent increase of women in the labor force. The demand for fresh potatoes was not influenced by substitute commodities, a finding consistent with those of Hee (1967), Zusman (1962) and Simmons (1962). These authors though did find substitutability among seasonal crops.

Though Estes recognized the gains in efficiency from using three-stage least squares, he refrained from using this method to avoid transmitting possible misspecification errors throughout the system. As parts of the model were estimated using ordinary least squares, maximum likelihood estimaters and two-stage least squares, a truly simultaneous analysis was not obtained. Though given a correct mapping of the various equations, no distortions should have resulted in the system. From this system, the author found that an increase in acreage planted in the Pacific Northwest would generally lead to decreased acreage in competing regions, decreased total U.S. acreage, but increased total U.S. production because of higher yields per acre. Potato prices were adversely affected by these market share gains for the Pacific Northwest.

Cardwell and Davis (1980) examined product forms and interseasonal competition in the U.S. potato industry. The authors estimated demand and supply equations for four production seasons: fall, winter, spring and summer. This study is significant in that it is the first to estimate separate demand equations for the four main product forms of potatoes: chips, frozen, dehydrated and fresh. To complete the model, potato storage and acreage were also estimated.

The estimated system of equations consisted of a general demand and supply model, a product form submodel and an acreage submodel. Estimates from the submodels were used as input into the general model. For example, the estimated demand quantities of the various product forms of potatoes were regressors in the seasonal demand equations. Most parameters in the submodels had signs as hypothesized. Several parameters in the general model had signs opposite of those hypothesized.

The own price parameter for each seasonal supply equation showed a downward sloping supply curve. The fall supply equation also showed a direct relation between input prices and production. Parameter values for the seasonal demand equations, save summer, had signs as hypothesized. Parameters for consumption of fresh potatoes and potato chips in the summer demand equation showed a decrease in the price of summer potatoes for increases in consumption of chips and fresh potatoes. These results were unexpected because most summer potatoes are consumed as chips and fresh.

Further findings of the study showed that fresh potatoes were more readily substituted for dehyrated products than for frozen products. Frozen products were more readily substituted for fresh potatoes than fresh for frozen. Income was found to have a positive effect on all processed forms, but a negative effect on fresh potatoes. Income elasticities for chips, dehydrated and frozen potatoes were .106, .280 and .451 respectively. An income elasticity of -.622 was found for fresh potatoes. Seasonal price flexibility coefficients were reasonably consistent with those of Hee (1967) and Zusman (1962). The price flexibility coefficient for fall potatoes showed a 3.44 percent decrease in price for each 1 percent increase in production. The authors noted that this fall coefficient was much larger than that found by Hee and Zusman. This difference was attributed to the larger share of fall production to total production in their 1958-77 data period as compared to earlier data periods used by Hee and Zusman.

Beilock (1981) conducted an econometric study of the potato industry which incorporated various features of the aforementioned studies, but also added new dimensions. Like Zusman, Beilock divided potato production into two six months seasonal markets; he then estimated national demands for them. Additionally, he attempted to incorporate risk in his supply equations and convenience preferences in his demand equations as his predecessor Estes had done. Further, potatoes for food were divided into uses similar to those used by Cardwell and Davis (1980). New dimensions included estimates of supply not only through the product of acreage and yield but also through direct estimates; estimates of national supply and demand equations for several product forms; estimates of regional supplies for these same product forms; and estimates of the impacts of energy cost on regional production.

The estimates, from both ordinary and two-stage least squares, generally revealed an inelastic supply at both the regional and national levels. Risk, defined as the variance of farm level potato prices was found to have a negligible impact on production. Both of these findings are consistent with those of Estes. Supply equations for the various product forms generally showed a shifting of supplies away from fresh toward processed, especially frozen potatoes. Additionally, as production in a region increased, supplies were allocated to all product forms as opposed to a specific form.

Unlike estimates from previous studies, Beilock's demand equation generally revealed larger demand elasticities for the dominant fall crop than for the smaller early crop. For example, a -.82 price elasticity was found for fall potatoes used as fresh and chips, but a -.34 elasticity for early potatoes for the same use. Yet, for the 1961-78 data period of this study, fall potatoes averaged 85 percent of production; early potatoes represented the remaining 15 percent. In estimating price elasticities for all potatoes used as food, Zusman (1962) found elasticities for the early crop to average two to four times higher than those for the fall crop. Though production as defined by Beilock (1981) and Zusman (1962) differed, the results seem to suggest that the demand for chips is much more elastic with respect to fall potatoes than with respect to early potatoes. As did Estes, the author found that no substitute product or commodity influenced the consumption of potatoes.

Unlike Estes, the author found very elastic as opposed to inelastic income elasticities. Additionally, though the products were not homogeneous, significant differences existed among the convenience elasticities of the two authors. Using the percentage of women in the labor force (WLF) as a proxy for convenience, Beilock's results revealed that the demand for frozen potatoes with respect to the dominant fall crop was essentially unaffected by changes in WLF; estimates by Estes, on the other hand, showed a 4.7 percent change in demand for processed potatoes for each 1 percent change in WLF. Though the estimates were for different commodities, it may be noted that frozen potatoes were the dominant processed form for both studies.

As the primary goal of Beilock's study was to examine the impact of rising energy cost on regional production, he simulated alternative energy scenarios. The results showed increased concentration of potato processing in the Northwestern region of the U.S. The author concluded that this result may have been expected as production of processed potatoes requires high energy costs, but transportation of these products requires relatively lower energy costs.

Present Study

The present study incorporates features from several of the aforementioned studies, but it is not a logical extension of any. For example, it attempts to account for risk in potato production and convenience preferences in demand, factors previously incorporated by Beilock and Estes. Also, as with these authors, separate demand equations are estimated for fresh and processed potatoes. Beyond these measures, similarities end. While the primary focus of all the reviewed studies has been some aspect of supply and demand, the present study focuses on the interaction of structural forces with supply and demand forces.

On the structural side, six endogenous variables are estimated: number of potato processing plants (NPP), concentration (CRP), price cost margins (PCM), advertising sales ratio (ASR), change in processing capacity (CCA), and utilization of processing capacity (UCA). These variables are linked to the supply and demand variables and estimated using three-stage least squares. The data period is from 1960 to 1981 with one year being the unit of time.

The estimated model is used to simulate the potato industry for alternative rates of growth of the exogenous variables. Additionally, policy variables are simulated and their impacts on the potato industry evaluated.

CHAPTER III
OVERVIEW OF POTATO INDUSTRY

Introduction

Changes in the U.S. potato industry have been rapid and widespread. All facets of the industry from production at the farm level to consumption at the household level have changed dramatically over the past three decades. Production of potatoes at the farm level not only has increased significantly but has shifted considerably among regions. Consumption of potatoes has shifted precipitiously from a predominance of fresh to a predominance of processed products. All of these described changes as well as others were precipitated primarily by the growing demand for processed potatoes. This chapter will therefore provide an overview of the potato industry with an emphasis on changes resulting from or associated with the growing demand for processed products.

Potato Production

During the past three decades, yearly potato production in the U.S. has increased by approximately 100 million hundredweights (Table 1.3). These increases occurred despite a more than 30 percent decline in acreage planted, a more than 45 percent decline in consumption of fresh potatoes, and a more than 95 percent decline in potato farms. Rising potato production obviously has been in response to factors which have at least offset the negative factors. Potato yields per acre, for example, have increased by more than 70 percent; consumption of processed potatoes has increased by over tenfold; and average farm size has increased by nearly thirtyfold. Prices received by potato producers have increased considerably during the most recent decade, but before this time they fluctuated inversely with production with no upward or downward trend discernible (Table 1.3).

Much of the increase noted in production has been due to shifts among production areas. Potato production in the Northeast, for example, has fallen from 29 percent of total U.S. production in 1950 to only 14 percent in 1980. Production in the Middle Atlantic region has fallen during this same period from 8 to 2 percent of total production. By comparison, production in the Pacific Northwest, as a share of total U.S. production, has risen during this period from 18 percent to 47 percent (Table 3.1). States comprising each region are defined in Table C.1. These shifts naturally have been from relatively low-yielding areas to high-yielding ones.

The economic stimuli for the above production shifts have been (1) higher relative productivity of land in the Pacific Northwest, and (2) lower transportation cost and higher value per pound of processed versus fresh potatoes. Both factors are significant because despite the greater

Table 3.1--U.S. Potato Production by Region, 1950-80

	Production in 1,000 cwts				Production as % of U.S. Total			
Region	1950	1960	1970	1980	1950	1960	1970	1980
Northeast	76,127	66,978	69,575	42,193	29.4	26.1	19.8	13.9
Middle Atlantic	19,327	15,469	11,330	7,010	7.5	6.0	3.5	2.3
Southeast	11,769	10,320	9,388	6,719	4.5	4.0	2.9	2.2
Lake States	25,171	22,225	29,026	28,705	9.7	8.6	8.9	9.5
Red River Valley	22,632	27,751	30,940	27,166	8.7	10.8	9.5	9.0
Pacific Northwest	45,551	60,991	123,479	143,520	17.6	23.8	37.5	47.4
California/Nevada	28,252	28,777	29,760	23,112	10.9	11.2	9.1	7.6
Central	30,283	24,398	27,254	24,432	11.7	9.5	8.4	8.1
U.S. Total	259,112	257,104	325,752	302,857	100.0	100.0	100.0	100.0

Source: *Potatoes and Sweetpotatoes* , USDA, various issues, 1950-1982.

productivity of land in the Pacific Northwest, the Northeast undoubtedly would have remained the largest producing region in the absence of differentials in transportation costs. Demographers will quickly discern that the logic of this argument stems from the proximity of the Northeast to large population centers.

The decline of farms producing potatoes far exceeds the decline of farms producing aggregate U.S. production. Whereas 3.7 million farms were producing agricultural products in 1959, this figure had declined to 2.5 million in 1978, a decline of 32 percent (Census of Agriculture). In contrast, potato farms declined during this period from 686 thousand to 28 thousand, a decline of 96 percent. These drastic losses of potato farms were primarily due to shifting demands from fresh to processed potatoes. These shifts have led not only to an abandonment of many farms which produced primarily for in-home consumption, but to an abandonment of farms which lost marketing outlets.

In summary, shifting potato production among regions has not just accompanied rising production, but has actually accounted for it. Shifting production also has led to fewer marketing outlets, especially outlets for fresh potatoes in the declining Northeast and Middle Atlantic regions. With fewer marketing outlets, marketing costs naturally increased because of increased distance to markets. Potato farms realizing prohibitive increases in marketing costs naturally ceased production.

Potato Consumption

Potatoes consumed in processed forms have increased tenfold during the past three decades. Consumption of fresh potatoes, by comparison, has plummeted to only one half its level three decades ago. An increase in consumption of processed potatoes may have been predicted as converting any product from its natural form to several processed ones usually increases total usage because of greater variety and increased convenience. Potatoes are not an anomaly. What is unusual about potatoes is the magnitude of decline in consumption of fresh potatoes coupled with a more than offsetting rise in consumption of processed potatoes.

Per capita consumption of fresh potatoes declined from 100 pounds in 1950 to 50.5 pounds in 1978 and then rose to 51.4 pounds in 1980; per capita consumption of processed potatoes rose from 6.3 pounds in 1950 to 70.6 pounds in 1978 and then declined to 64.4 pounds by 1980 (Table 3.2). While several processed potato products have generated this growth, frozen potatoes have played the most pronounced role. Much of this growth of frozen potatoes has resulted from the increased usage of these products at institutional establishments (restaurants, hotels, lunchrooms, etc.).

Frozen french fries, dehydrated mashed, and potato chips are the major processed potato products. Small quantities of potatoes are canned and processed into starch and flour. Potato chips, the first processed potato product, led the growth or potato processing until the mid 1960's. By 1966,

Table 3.2--U.S. Per Capita Consumption of Fresh and Processed Potatoes, 1950-80
(Pounds on Fresh-weight basis)

Year	Total fresh and processed	Fresh	Processed	Chips and dehydrated	Processed forms: Chips	Dehydrated	Frozen	Canned
1950	106.3	100.0	6.3	5.7	--	--	0.3	0.3
1951	113.6	106.8	6.8	6.0	--	--	.6	.2
1952	101.9	93.8	8.1	6.7	--	--	.9	.5
1953	107.8	99.1	8.7	7.3	--	--	.8	.6
1954	107.1	98.1	9.0	7.6	--	--	1.1	.3
1955	108.9	98.1	10.8	8.4	--	--	1.8	.6
1956	102.8	90.3	12.5	9.0	--	--	2.9	.6
1957	109.4	94.2	15.2	11.7	--	--	2.9	.6
1958	104.5	87.6	16.9	12.9	--	--	3.4	.6
1959	106.5	86.2	20.3	14.9	--	--	4.9	.5
1960	108.2	84.4	23.8	16.8	11.9	4.9	6.4	.6
1961	103.3	84.4	24.9	17.4	--	--	6.8	.7
1962	108.1	80.4	27.7	17.9	--	--	9.2	.6
1963	112.1	81.8	30.3	19.1	--	--	10.7	.5
1964	110.0	75.1	34.9	20.3	--	--	14.0	.6
1965	107.0	68.2	38.8	22.8	15.8	7.0	14.3	1.7
1966	116.8	72.4	44.4	25.4	16.7	8.7	17.3	1.7
1967	108.0	62.0	46.0	25.3	16.9	8.4	19.0	1.7
1968	115.2	65.9	49.3	26.2	17.1	9.1	21.2	1.9
1969	116.9	61.7	55.2	28.6	17.7	10.9	24.6	2.0
1970	117.5	59.2	58.3	29.5	17.7	11.8	27.7	2.0
1971	118.7	56.8	61.9	29.4	17.3	12.1	30.3	2.2
1972	119.4	57.4	62.0	29.3	17.0	12.3	30.6	2.1
1973	116.8	51.9	64.9	29.4	16.6	12.8	33.2	2.9
1974	114.3	48.4	65.9	30.6	16.1	14.5	33.0	2.3
1975	122.1	55.0	67.1	30.4	15.9	14.5	34.7	2.0
1976	116.1	51.0	65.1	26.2	16.1	10.1	36.9	2.0
1977	121.6	51.5	70.1	27.9	16.7	11.2	39.9	2.3
1978	121.1	50.5	70.6	28.8	17.3	11.5	39.5	2.3
1979	115.6	51.5	64.1	26.6	17.1	9.5	35.4	2.1
1980	115.8	51.4	64.4	28.5	17.0	11.5	33.8	2.1

Source: O. Hee, Demand and Price Analysis for Potatoes, 1967, p. 25; and U.S. Dept. of Agriculture, *Vegetable Situation*, Nov. 1979, Nov. 1980, and Oct. 1981.

per capita consumption of frozen potatoes had surpassed that of chips, had more than doubled chips by 1975, and has maintained this 2 to 1 ratio into the 1980's (Table 3.2). Although a variety of frozen potato products are produced (hash browns, diced, scalloped, etc.), frozen french fries constitute over 80 percent of all frozen potatoes. Moreover, french fries account for more than half of all frozen vegetables.

While the preceding description of changes in potato consumption may reveal much about the potato industry, identifying and then discussing those factors which caused these changes is obviously of importance to researchers. While many factors have precipitated these changes, some of the more significant ones are believed to be changing consumers' tastes, rapid growth and expansion of fast food establishments, an increasing number of women in the work force, a growing population, and an increasing number but declining size of households.

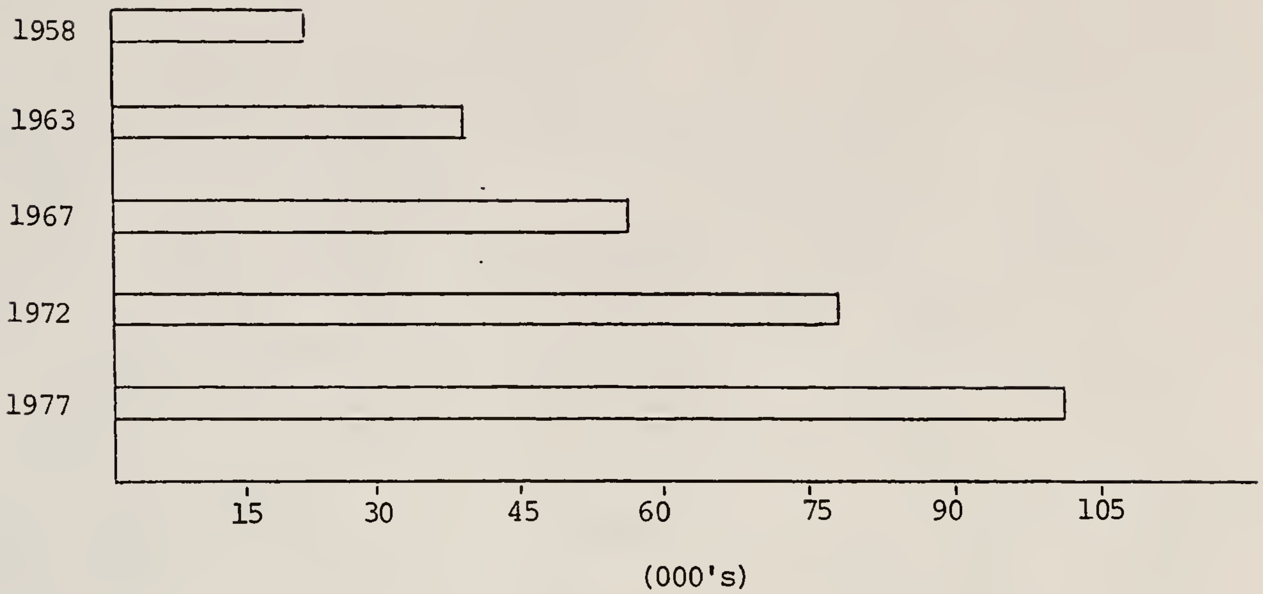
Fast Food Establishments

Frozen french fries, the processed potato product which has shown the most significant growth, are channeled primarily through fast food establishments. According to potato marketing specialists, roughly 60 percent of all frozen french fries is channeled through fast food establishments. With the 1981 production of frozen french fries totaling 3.6 billion pounds, this means that roughly 2.2 billion pounds of these fries were sold at fast food establishments. The leading fast food chain, McDonald's, is estimated to account for 25 percent of all frozen fries (Cox, 1982). These figures then translate into sales of 900 million pounds of french fries in 1981 at McDonald's establishments.

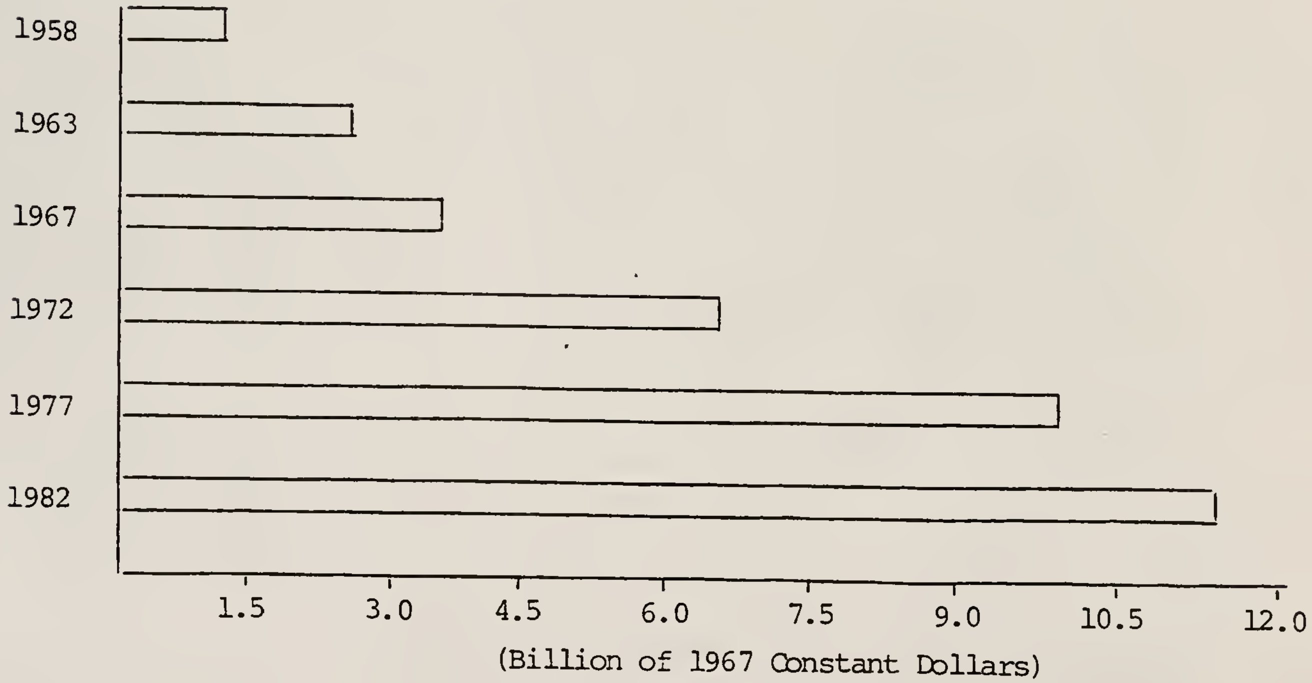
Frozen french fries are not only marketed primarily through fast-food establishments but also account for roughly 20 percent of fast-food sales (Purcell 1976; Cox 1982). Cox (1982) reports that seven of every ten customers arriving at fast food establishments after breakfast are estimated to order fries as part of their entree. Given this importance of frozen fries at fast food establishments, some correlation between the growth of frozen potatoes and the fast food industry may be expected. Indeed both have shown tremendous growth.

The number of fast food establishments increased fourfold during the 1958-77 period. In actual numbers, these establishments rose from 25.1 to 100.5 thousand. Sales at these establishments increased ninefold, rising from $1.1 billion in 1958 to $11.8 billion in 1982 (Figure 3.1). With 20 percent of fast food sales being comprised of frozen french fries, dollar sales of fries at these establishments then totaled $2.3 billion.

The described growth of the fast food industry has given a tremendous boost to consumption of processed potatoes, via frozen french fries. Other processed potato products have yet to gain marketability at fast food establishments,



Number of Fast Food Establishments, 1958-77



Sales at Fast Food Establishments, 1958-1982

Figure 3.1. Fast Food Establishments by Number and Sales

though it is not inconceivable that chips and dehydrated potatoes could become competitive products at these establishments. Fresh potatoes already appear to be gaining a reasonable share of fast food sales. This marketing outlet for fresh potatoes may prove to be the requisite stimuli to arrest the decline in consumption of fresh potatoes.

Women in the Work Force

An increasing percentage of women in the labor force supposedly shifts demand toward food products which require little preparation time at home. In essence, women in the labor force increase the demand for convenience foods. Because processed potatoes represent or contain convenience, growth of women in the labor force is expected to stimulate growth of processed potatoes. Labor force data reveal that women as a percentage of the labor force have grown from 29 percent in 1950 to a 1982 level of 43 percent. This growth then represents an increasing demand for the convenience reflected in processed potatoes. Because women have less time and energy to devote to food preparation, market baskets of today clearly contain more products reflecting increased convenience.

This described growth in demand for convenience has not only influenced the characteristics of market baskets, but has accelerated the growth of fast food establishments. Diners of fast food restaurants list convenience as the primary reason for their patronage. These diners define convenience as not having to (a) cook, (b) do dishes, (c) wait for service, or (d) travel far (Restaurant Business, May 1982). Thus a growing demand for convenience alters both in-home and away-from-home food consumption.

Population

Growth of total potato usage during the early 1960's resulted primarily from an expanding population as per capita consumption remained fairly constant. Since the mid 1960's, per capita consumption of potatoes has increased but population growth is hypothesized to have continued its positive effects. These effects should be especially noticeable for frozen potatoes since considerable growth has occurred in that segment of the population which frequently consumes these products at fast food establishments. That is, surveys by Restaurant Business (May 1982) have found that the 25 to 44 age group, which has a greater tendency to eat out, has shown and continues to show considerable growth.

Number and Size of Households

Consumption of processed potatoes during the past two decades has been influenced by a growing number but declining size of households. Declining household sizes supposedly have increased the potential for away-from-home food consumption by decreasing the cost of eating out while simultaneously increasing the inconvenience of eating-in. These changing consumption patterns increase the expected growth of frozen potato products because of their heavy institutional uses, but decrease the expected growth of other processed potato products because of their primarily in-home uses.

Consumers Taste

Changing consumers' taste is believed to be a factor in influencing the shift in consumption from fresh to processed potatoes. While it is impossible to quantify taste or its impact on demand, it may be noted that potato processors have stressed improved taste and nutrition of its products. So there is at least a perception that consumers' decisions are a function of taste. However, it should be recognized that differentials exist in the time periods for which fresh and processed potatoes have been available. That is, it may be appropriate to distinguish between a shifting taste and a developing taste for processed potatoes. Since neither can be quantified, suffice it to say here that taste is believed to have influenced the demand for potatoes.

Implications

The changing composition of potato consumption from fresh to processed forms has implications for consumers, producers and processors. From one perspective, higher proportions of potatoes consumed as processed mean more consistent quality, longer storability, and increased convenience for consumers (Quick Frozen Foods, June 1977). From another perspective, consumers are confronted with higher costs and a loss of nutrients from increased consumption of processed potatoes (Talburt and Smith, 1975).

Producers, because of increased sales to processors through contracts, are believed to have realized a reduction of price risk and an enhancement of creditworthiness with bankers. Processors are believed to have realized a reduction in production costs, a higher quality of raw products, and a more timely delivery of raw products.

While the positive attributes of processed potatoes have undoubtedly increased utility for consumers, the supposedly negative attributes--increased cost and fewer nutrients--must be evaluated with caution when making comparisons with fresh potatoes. Most comparisons of cost per servings of processed with fresh potatoes show a higher cost for processed. These comparisons though, almost invariably fail to account for the differentials in labor requirements for preparing each form. Talburt and Smith (1975) have found that imputing a mere $.50 per hour to the cost of time for food preparation results in a favorable comparison of cost per serving of processed with fresh potatoes. Additionally, nutritional comparisons must also be made with caution. Most nutritional comparisons involve processed potatoes with fresh-dug potatoes. However, potatoes stored for a mere three months, not uncommon for fall potatoes, can lose as much as 50 percent of its primary nutrient, ascorbic acid (Vitamin C). Processed potato products, on the other hand, are virtually unaffected by storage. Thus, on balance, processed potatoes could compare favorably with fresh potatoes when the cost of time and the losses from storage are considered.

Increased potato processing is believed to have favorably impacted the quality of potatoes marketed as fresh. As the potato processing industry matured and processors became larger and more diversified, potatoes which were most appealing in size, shape and form were sorted by processors for fresh marketing. This selected sorting resulted not only in higher average quality of fresh potatoes, but in reduced time and expenses of consumers' search for quality. Simply put, it led to more efficient marketing of potatoes.

Before the tremendous expansion of potato processing, raw potatoes were sold primarily to potato chip processors and fresh buyers. Both raw potato producers and chip processors were concentrated around large population centers, particularly the Northeast region. These locations were determined from the economics of transportation costs. With demand shifting from fresh to processed potatoes, raw producers have found less populated but more productive areas to concentrate their production. Potato chip processors, on the other hand, are still optimally served by large population centers.

The dramatic growth of frozen and dehydrated potato products, as noted previously, has been accompanied by a significant loss of potato farms. And while there has been significant increases in yields per acre, tremendous increases have also occurred in average farm sizes. From 1959 to 1978, the average sized potato farm jumped from 1.75 acres to 48.9 acres. Part of the economic stimulus for these increases in farm size resulted from raw product specifications of processors. Small producers, because of unavailable technical assistance, generally have been unable to produce potatoes with consistent processing characteristics--high solids, low and uniform sugars, and good type (Gomena, 1968). Because the probability of technical assistance from processors increases with farm size, many producers have either expanded or ceased production.

Potato processors have suggested that increased potato processing has reduced their production cost, improved the efficiency of their operations, and enhanced the quality and uniformity of processed products (Conrad, 1975). Processors contend that because they have become increasingly larger, contract purchases are imperative for efficient operation. Contract purchases, according to processors, reduce the price risk associated with open-market purchases; since price risk is an element of cost, a reduction in price risk should therefore reduce production cost. Efficiency of operations, according to processors, has been enhanced because of the timely deliveries generated through contracting. That is, processors incur less search cost in obtaining raw potatoes. Processors further contend that their smaller number coupled with their increased size has resulted in improved product quality. Improved quality, it is argued, results from competition among processors for consumers' dollars. Because consumers will readily switch brands upon variations in quality, processors have consistently provided uniform quality. Before the decline in number and increase in size, processors contend that uniformity and consistency of quality were sacrificed because smaller processors maintained variable production standards.

In the movement to fewer and larger potato processors, it may be noted that larger processors often acquired smaller firms, marketed the acquired product brands, but closed the facilities producing these brands. An indication of the impacts resulting directly and indirectly from actions of larger processors is reflected in the changes in potato processing plants. Whereas 400 plants were producing potato chips in 1960, by 1980 this number had declined to 177. Plants processing frozen potatoes increased from approximately 30 in 1960 to 91 in 1964, but declined to only 33 in 1980. Dehydrated potato processing plants increased from an estimated 21 in 196) to 28 in 1964, but declined to 19 by 1980. These plant changes are believed to reflect the impacts of differentiated product advertising and the increased cost of adopting new technology.

Summary and Conclusion

Dramatic economic changes have occurred in the U.S. potato industry during the past three decades.

Technological advances in agriculture coupled with regional shifts in potato production have greatly augmented farm-level potato production. Additionally, technology has increasingly added convenience to potatoes via the development of new varieties of potato chips, frozen french fries, dehydrated mashed, and other processed products. Changing socio-economic conditions have influenced taste preferences of American consumers to an extent that they are now expressing a stronger preference for processed than for fresh potatoes. A question of relevance here is whether these described changes also characterize the future of the potato industry?

Potato production at the farm level is constrained more by demand conditions than by technological know-how. Advances in technology therefore, are not likely to greatly increase total production. Potato farms, however, are expected to continue increasing in size because farm technologies are generally land-using. Hence, there are likely to be fewer farms with potato production further concentrated in the Pacific Northwestern states of Idaho, Oregon and Washington. Further concentration of production in these areas also is likely to lead to further concentration of processors

Technological advances in the processing of potatoes are expected to add more convenience to processed products. These convenience aspects most likely will be reflected as less food preparation time, more fortified and retained nutrients, more palatable taste, and longer storability. These aspects probably will increase in significance as women become a larger share of the labor force. Fast food establishments also are likely to find these attributes of growing significance because of the importance of convenience to their patronage.

If processors can add more convenience to processed products, consumption of these products undoubtedly will increase. Increased advertising and promotion of both fresh and processed potatoes may also further enhance potato consumption. Indeed advertisers and promoters of fresh potatoes argue that the recently enacted Research and Promotion tax has not only arrested the decline but actually increased consumption of fresh potatoes. Accelerating the per capita consumption of fresh and processed potatoes should lead to tremendous growth of the potato industry.

CHAPTER IV
DEVELOPMENT OF ECONOMIC MODEL

Introduction

In this chapter a simultaneous equation model is specified which captures and explains the dramatic economic changes that have occurred in the potato industry. Figure 4.1 provides an illustration of the vertical market structure of the potato industry. Exogenous and endogenous factors which have both structural and market equilibrium dimensions impact the entire vertical system and the overall performance of the industry. Performance, in turn, impacts the endogenous factors.

The model specified in Table 4.1 captures the schematics which Figure 4.1 illustrates. The model consists of sixteen endogenous and twenty exogenous variables; all variable symbols and definitions are provided in the notes to Table 4.1. Following the equations and variables specification is a theoretical discussion of each equation and variable. For expository purposes, the model as specified in Table 4.1 is subdivided into two sectors: (1) structural, and (2) market equilibrium (price-demand-supply). Equations 4.1 through 4.6 are structural while the remaining 4.7 through 4.16 express dimensions to market equilibrium. These two sectors are hypothesized to have impacts on the model that differ with respect to time. While only a superficial discussion of this time-dimension problem is presented here, a thorough and more profound discussion follows in Chapter V.

The Structural Sector

The field of industrial organization is rich with studies on the structure and performance of industries. These studies predominantly estimate single-equation models in which causality runs from structure to performance. The model specified in Table 4.1 is both dynamic and simultaneous with respect to the structural variables. Equation 4.1 attempts to capture those factors influencing and determining the number of processing potato plants (NPP). The number of plants not only is influenced by several variables, but NPP, in turn, influences several variables. Concentration (CRP), as measured by equation 4.2, is also impacted by and impacts several variables within the model. Equation 4.3 captures those factors determining the price-cost-margins (PCM). These margins influence other variables, particularly those within the market equilibrium sector. An advertising-sales ratio (ASR) is determined by Equation 4.4. Equation 4.5 measures changes in processing capacity (CCA) while 4.6 measures utilization of capacity (UCA). These six equations are highly interrelated and are intended to capture the structural dimensions of the potato industry. Among other relationships, it may be observed that PCM influences NPP;

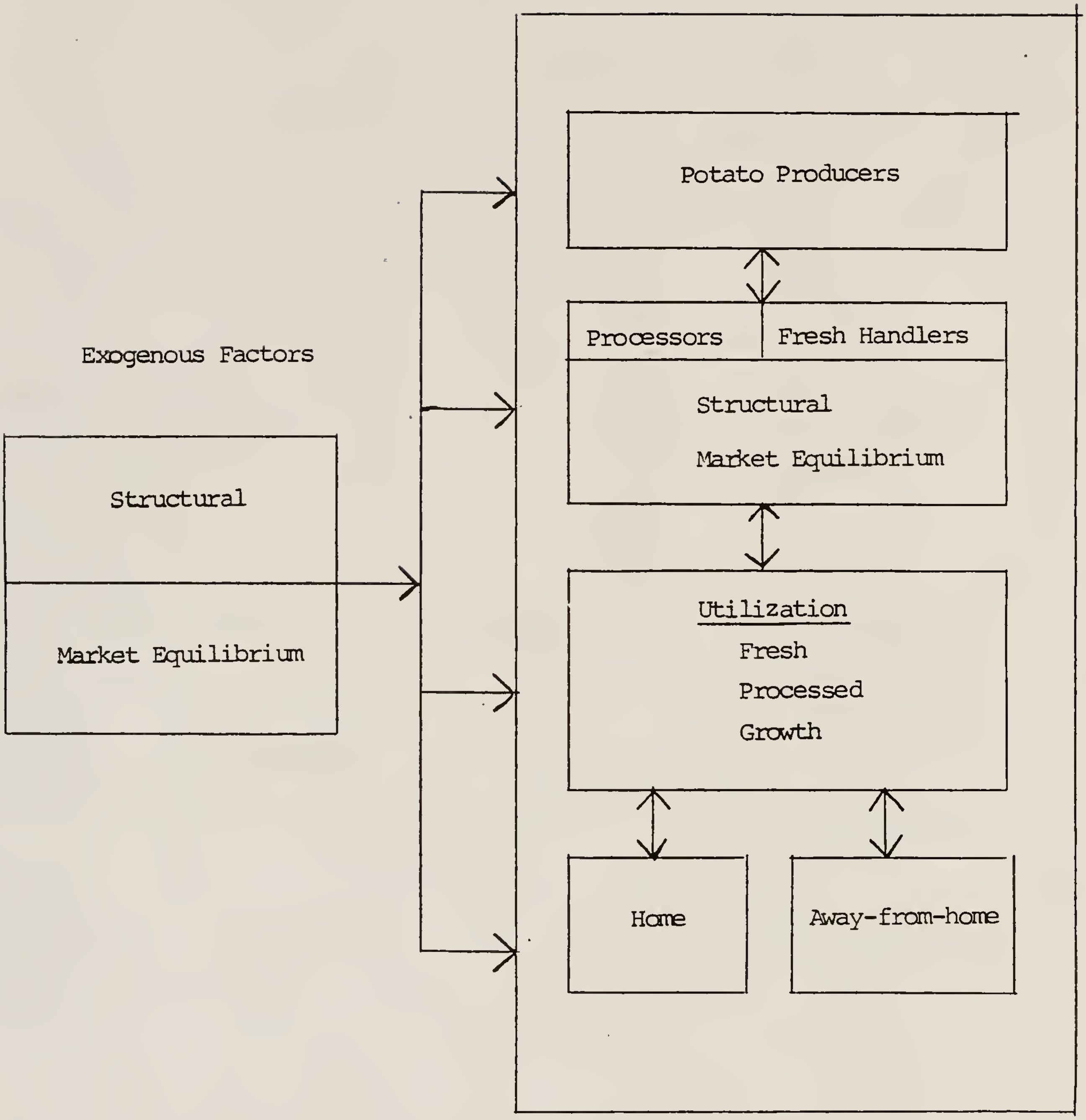


Figure 4.1. Schematic Diagram of the Potato Industry

Table 4.1--System of Equations for Analyzing the U.S. Potato Industry

Eq.	Endogenous Variables																
	NPP	CRP	PĊM	ASR	CCA	UCA	QṘP	UZF	UZP	RPF	RPP	WPP	FPR	RPT	SPR	UZO	C
4.1	-1		Γ_{13}			Γ_{16}											Π_{10}
4.2	Γ_{21}	-1		Γ_{24}													Π_{20}
4.3		Γ_{32}	-1			Γ_{36}											Π_{30}
4.4		Γ_{42}		-1				Γ_{48}	Γ_{49}								Π_{40}
4.5	Γ_{51}				-1	Γ_{56}											Π_{50}
4.6	Γ_{61}				Γ_{65}	-1			Γ_{69}								Π_{60}
4.7							-1										Π_{70}
4.8								-1		$\Gamma_{8,10}$	$\Gamma_{8,11}$			$\Gamma_{8,14}$			Π_{80}
4.9				$\Gamma_{9,4}$					-1	$\Gamma_{9,10}$	$\Gamma_{9,11}$			$\Gamma_{9,14}$			Π_{90}
4.10										-1			1		1		
4.11											-1	$\Gamma_{11,12}$					$\Pi_{11,0}$
4.12			1									-1	1				
4.13							$\Gamma_{13,7}$						-1				$\Pi_{13,0}$
4.14								.01	.01					-1			
4.15															-1		$\Pi_{15,0}$
4.16							-1	1	1							1	

Table 4.1--Continued

Eq.	Exogenous Variables																			
	MS	PCML	CT	GD	CK	PS	FPRL	MC	TR	RS	GC	TF	FF	PN	IN	WN	GR	UZPL	QRPL	ASRL
4.1	Π_{11}	Π_{12}	Π_{13}	Π_{14}													$\Pi_{1,17}$	$\Pi_{1,18}$		
4.2	Π_{21}	Π_{22}	Π_{23}		Π_{25}															$\Pi_{2,20}$
4.3		Π_{32}																		
4.4		Π_{42}		Π_{44}													$\Pi_{4,17}$			
4.5		Π_{52}			Π_{55}															
4.6		Π_{62}																		
4.7						Π_{76}	Π_{77}		Π_{79}	$\Pi_{7,10}$									$\Pi_{7,19}$	
4.8											$\Pi_{8,11}$	$\Pi_{8,12}$	$\Pi_{8,13}$	$\Pi_{8,14}$	$\Pi_{8,15}$	$\Pi_{8,16}$				
4.9											$\Pi_{9,11}$	$\Pi_{9,12}$	$\Pi_{9,13}$	$\Pi_{9,14}$	$\Pi_{9,15}$	$\Pi_{9,16}$				$\Pi_{9,20}$
4.10																				
4.11									$\Pi_{11,9}$											
4.12																				
4.13																			$\Pi_{13,19}$	
4.14																				
4.15								$\Pi_{15,8}$												
4.16																				

Table 4.1 Continued

	Endogenous Variables
NPP	Number of processing plants
CRP	Concentration in potato processing
PCM	Price cost margins
ASR	Advertising sales ratio
CCA	Change in processing capacity
UCA	Utilization of processing capacity
QRP	Production of fresh potatoes
UZF	Utilization of potatoes for fresh consumption
UZP	Utilization of potatoes for processing
RPF	Retail price of fresh potatoes
RPP	Retail price of processed potatoes
WPP	Wholesale price of processed potatoes
FPR	Farm price of fresh potatoes
RPT	Research and promotion tax
SPR	Spread between retail and farm price
UZO	Utilization of other potatoes

	Exogenous Variables
MS	Minimum efficient plant size
PCML	Price cost margins lagged
CT	Transportation cost
GD	Geographic dispersionof potato production
CK	Cost of capital
PS	Price of sugar beets lagged
FPRL	Farm price of fresh potatoes lagged
MC	Marketing cost
TR	Trend variable
RS	Risk
GC	Produce sales through retail grocery stores
TF	Total away-from-home restaurants food sales
FF	Fast-food sales as a percent of total food
PN	Population
IN	Income
WN	Women in labor force
GR	Expected growth
UZPL	Utilization of potatoes for processing lagged
QRPL	Production of fresh potatoes lagged
ASRL	Advertising sales ratio lagged

NPP influences both CRP and CCA; CRP influences ASR; and CCA influences UCA. Other relationships among these structural and market equilibrium variables follow in the discussion of each equation.

Number of Potato Processing Plants

Equation 4.1 estimating the number of potato processing plants (NPP) represents a proxy equation for the more appropriate one, the number of firms. While there is unlikely to be a one-to-one correspondence between changes in plants and firms, a sufficiently high correlation is expected to exist so as not to distort the explanatory proficiency of the model. This expected result stems from the entry and exit patterns of potato processing firms.

Potato chip processors have always dominated the potato processing industry as measured by the number of firms and plants. Entry into potato chip processing was rapid and extensive following World War II, consisting mostly of small producers. As the industry grew and matured, consumers began demanding fresh, unbroken, and ungreasy chips (Warwick, 1973). To satisfy as a minimum the first two demand characteristics, potato chip processors began implementing a marketing system of delivering their products from plant to retail outlets. Because the volume of production of many smaller processors could not sustain these additional marketing costs, these firms were either purchased by larger ones or exited the industry. Similar changes also occurred in the frozen potato sector, but exit of smaller firms was due primarily to shifts in marketing from retail to institutional establishments and increases in advertising expenditures by larger producers. Institutional establishments demanded from processors a level of product uniformity and specificity that smaller firms often found unprofitable to produce. The limited diversification of the smaller firms typically could not support production of by-products which helped to sustain the profitability of larger firms. Advertising by larger producers also helped to erode market shares of smaller producers. Unlike chips and frozen potato production, dehydrated production was never inundated by smaller producers.

The equation as specified in Table 4.1 to measure the number of potato processing plants is

(4.1) $NPP = f(PCM, UCA: MS, PCML, CT, GD, GR, UZPL)$

Price-cost-margins (PCM) are expected to be significant in firms' exit decisions, but PCMI are hypothesized to be of greater significance in firms' entry decisions. Stated differently, low PCM will most likely influence the decision of marginal firms to exit the industry while longer time periods will be needed for firms to enter the industry because of time required to bring new plants into production. Positive coefficients are expected for both PCM and PCML as firms are hypothesized to respond affirmatively to improved profit conditions.

Theoretically, rising margins should induce firm entry or, as a minimum, increase firm size. Similarly, falling margins should precipitate or accelerate the exit of firms as marginal firms' costs rise above product prices. Moreover, an increasing demand which raises capacity utilization (UCA) and profitability of an industry should escalate the number and size of firms. That is, lower rates of capacity utilization are likely associated with slackening demand and therefore lower PCM, while higher rates of UCA are likely associated with increasing demand and a higher profit rate (Sawhney and Sawhney, 1973). This hypothesized positive relationship between NPP and PCM is also expected to characterize that between NPP and UCA.

Several exogenous or predetermined variables are hypothesized to impact NPP. As the minimum efficient plant size (MS) increases, small firms with limited shares are likely to exit the industry as their competitiveness with larger firms diminishes. Minimum efficient plant size may be affected by several factors. Among these are transportation cost, capital cost, volume discounts, and market size. These factors are believed to be reflected in changes in average plant size. And while the average size of existing plants changes, size of new plants is considered the most appropriate measure. MS therefore reflects the average size of plants coming on stream within a particular year.

Lagged price cost margins (PCML) have been discussed in conjunction with PCM. A one period lag is expected to be sufficient for capturing the requisite time horizon for adding new plants. Lagged utilization of processed potatoes (UZPL) also represents a one period lag as processors are expected to adjust their plants according to the previous year's changes in processed potatoes. In general, processors should be expected to increase NPP as UZPL increases. However, NPP could decrease with increased UZPL if significant product differentiation, advertising expenditures, cost differences, and other entry barriers should effectively hamper the competitiveness of smaller firms with larger ones. These factors, which are accounted for in the model, indirectly affect NPP and could lead to a relatively insignificant coefficient for UZPL.

Since firms generally expand and contract their operations based on some expectation of future growth, NPP should be directly related to expected growth (GR). For the processed potato industry, GR is likely to be based on a number of factors such as recent changes in sales, income, per capita potato consumption, women in the labor force, and away-from-home food consumption. Changes in demand for processed potatoes during the previous three years should capture most of these forces. Hence, GR is defined as UZP lagged three periods with equal weights per period.

The impact of transportation cost (CT) on NPP cannot be determined apriori. With CT being a significant proportion of marketing costs, firms may be expected to add plants in an attempt to minimize total marketing cost. Transportation cost, however, is only one component of marketing cost. Other components may be changing at a rate which would offset advantages to be gained from a more efficient spatial distribution of plants. Furthermore, economies of scale in production may favor concentrated production over more dispersed production.

Although the sign of CT is indeterminate, geographic dispersion of raw potato production (GD) is expected to have a significant and positive effect on NPP. Transportation cost relative to the value of raw potatoes virtually dictates the spatial allocation of processing plants in some proportion to GD. With raw potato production becoming increasingly concentrated in the Pacific Northwest, a growing concentration of plants in this area may be hypothesized.

Concentration in Potato Processing

Although there are many indexes for measuring concentration, this study utilizes a four-firm concentration ratio. This measurement is chosen based on data availability rather than theoretical reasoning which precludes other measures. hile the consideration of only a point on the concentration curve is a valid criticism of this measure, the use of time-series data over twenty-two years is expected to negate this criticism. Concentration is therefore expected to yield reasonable measurements of changes in concentration.

As NPP increases, concentration is expected to decrease because new plants should reflect firm entry. This hypothesized relationship is somewhat tentative since concentration could increase as larger firms with large market shares add plants. It is assumed, however, that new plants are more prone to result from firm entry than from expansion of larger firms. Larger firms, it is assumed, are more likely to increase production through additional shifts and expanded plant sizes.

(4.2) CRP = f(NPP, ASR: MS, CT, PCML, CR, ASRL)

The impact of advertising expenditures on entry of firms into an industry is well documented (Schmalensee, 1976 and Strickland and Weiss, 1976). The consensus of these authors is that advertising expenditures tend to be highly correlated with the degree of product differentiation and the more products are differentiated, the higher the degree of concentration. Logically, then, advertising expenditures on processed potato products should increase as concentration within the industry increases, yielding a positive coefficient for advertising-sales-ratio (ASR).

Focusing on the predetermined or exogenous variables, theoretically a positive relationship between minimum efficient plant size (MS) and concentration (CRP) should exist. An increasing MS is likely to accompany or result from technological changes. Larger firms not only are more prone to first adopt these technologies, but also are more likely to expend funds on research and development to develop them (Hay and Morris, 1979).

The impact of transportation cost on CRP is indeterminate. If rising CT should lead to more plants and by assumption more firms, then a negative partial derivative would be anticipated. On the other hand, if NPP should be inversely impacted by CT, then CRP should be positively impacted by this variable.

Theory does not suggest the direction of change lagged price-cost-margins (PCML) will have on CRP. High PCML may induce firm entry or simply provide the necessary incentives for larger firms to erect more formidable entry barriers while simultaneously increasing their market shares and profits. To the extent that high PCML are likely associated with product differentiation and other entry barriers, one would be inclined to hypothesize a positive relationship between PCML and CRP.

Capital cost (CK) is expected to have a positive effect on CRP. The cost of capital is frequently the most effective constraint prohibiting smaller firms from adopting technological changes which would maintain their competitiveness with larger firms.

Lagged advertising-sales-ratio (ASRL) is expected to bear the same positive relationship to CRP as ASR bears to CRP. In fact, because of the adjustment process, ASRL may have a more significant effect on CRP than ASR. That is, firm entry or exit is more likely to be based on previous advertising expenditures than on current expenditures, partly because information on previous expenditures is more readily available.

Price Cost Margins

The price-cost-margins equation is specified as a function of two endogenous and one predetermined variable.

(4.3) PCM = f(CRP, UCA: PCML)

The importance of CRP as a variable influencing PCM follows directly from oligopoly theory which predicts an increase in the effectiveness of tacit collusion as concentration increases. This indicates that firms with large market shares are prone to raise prices above the competitive level as concentration increases. Within the processed potato industry, larger firms ostensibly could increase prices without experiencing significant market losses because of consumers' preferences for their differentiated products. A positive coefficient is therefore expected for CRP.

Utilization of capacity (UCA) is considered a relevant variable in this equation because it indirectly indicates demand conditions for the product. Sawhney and Sawhney (1973) have shown that high capacity utilization is likely to correspond to increasing product demand because firms are in a more favorable position to pass on cost increases. High capacity utilization also is likely to reduce costs associated with underutilization. Utilization of capacity is therefore expected to have a positive coefficient.

While only two endogenous variables directly impact PCM, other endogenous variables such as the number of processing plants and the retail price of processed potatoes are influenced by PCM. Table 4.1 shows that the retail price of processed potatoes influences several variables and equations within the market equilibrium sector. These interrelationships verify the simultaneity of the model.

Turning to the predetermined or exogenous variable, PCML are expected to be an important determinant of current PCM because margins indicate the effectiveness of processors' market power. It is hypothesized that high price cost margins in the current period are followed by high margins just as low margins in the current period are likely to be followed by low margins. The possibility always exists though that firms will raise their margins when they are low to increase profits, and lower margins when they are high to avoid attracting competitors. This scenario would indicate the absence of effective market power which is expected to be a characteristic of the processed potato industry.

Advertising Sales Ratio

The advertising-sales ratio is influenced by several endogenous and predetermined variables and, in turn, it influences several endogenous variables. This equation is linked to the market equilibrium sector through its impact on UZP; UZP then impacts three of the six structural equations, thereby clearly identifying interrelationships between the two sectors. This equation is specified as

(4.4) ASB = f(CRP, UZF, UZP: PCML, GD, GR)

Theoretically, rising concentration should increase the level of advertising because non-price competition becomes a more feasible method for increasing sales (Ward and Behr, 1980). This expected result stems from the Dorfman-Steiner model which suggests that the optimal level of advertising expenditures for a firm occurs where the marginal revenue product of advertising equals the absolute value of the elasticity of demand for the firm's product (Dorfman and Steiner, 1954). And since the price elasticity of demand faced by a firm is lower in more concentrated industries, advertising expenditures are predicted to increase with concentration. Concentration is therefore expected to have a positive coefficient.

Utilization of fresh potatoes (UZF) is considered an important variable in this equation because of relative differences in advertising expenditures on fresh and processed potatoes. With fresh potatoes being advertised primarily as a generic product, advertising expenditures are comparatively low versus the differentiated processed potatoes for which advertising helps accentuate product differences. As the demand for fresh potatoes increases, ceteris paribus, advertising expenditures are expected to decline. By contrast, growing demand for UZP is expected to increase ASR. Mathematically, a negative coefficient is expected for UZF but a positive one for UZP.

Considering the predetermined variables, PCML is hypothesized to provide some indication to processors as to the need for advertising expenditures. As previously suggested, the sign of this variable cannot be determined a priori. Low or falling PC L may suggest a need for more advertising expenditures to raise margins whereas rising margins may suggest a need to increase advertising expenditures to gain larger market shares and power or, at least, maintain existing shares and power. It is hypothesized that this last mentioned condition is likely to prevail, particularly since rivals also are likely to increase their advertising expenditures.

The more geographically dispersed production (GD), the smaller is likely to be the level of advertising because there is likely to be more firms with a smaller share of the total market. Though the possibility always exists that such market structure may encourage national firms to increase their advertising expenditures in an effort to force regional or local firms from the industry. Since the first mentioned condition is more likely to prevail, a negative sign is hypothesized for GD.

Changes in expected growth (GR) are expected to be highly correlated with advertising. In fact, processors are expected to use advertising expenditures to aid formation of their expectations. As a result, a positive sign is expected for this parameter.

Change in Processing Capacity

Capacity changes in the processed potato industry are likely to respond to existing and expected demand conditions. Identifiable exogenous variables which are expected to reflect these conditions are NPP and UCA. While UCA is reflective of existing demand conditions, NPP reflects both existing and expected demand conditions as future expectations are of considerable importance in firms' decisions to add new plants. Increases in NPP and UCA should positively impact CC because such increases suggest rising demands for processing potatoes.

(4.5) $CCA = f(NPP, UCA: PCML, CK)$

Lagged price-cost-margins and the cost of capital are the two exogenous variables which are hypothesized to impact CCA. As PCML increase, firms are expected to increase processing capacity because this variable provides an indication of the future profitability of the industry. The cost of capital (CK) indicates a measure of constraint on capacity changes and is therefore expected to have a negative coefficient.

Utilization of Processing Capacity

The percent of processing capacity utilized is likely to be highly correlated with changes in capacity and demand conditions for processed potato products. An increase in

NPP is likely to lower UCA unless there are concurrent increases in demand which more than offset increases in additional capacity. Also, as small firms with traditionally small plants and comparatively low utilization rates exit the industry, the level of utilization associated with full capacity should increase (Gabel, 1979). Increases in CCA are expected to lower UCA because of time adjustment lags in demand and total capacity changes. Thus, the coefficients of both NPP and CCA are expected to be negative.

(4.6) UCA = f(NPP, CCA, UZP: PCML)

Utilization of capacity is expected to increase in response to rising UZP because UZP represents existing demands for processed potatoes. Similarly, UCA should increase in response to an increase in PCML as higher margins should suggest growing demand or, as a minimum, more concentrated production and therefore less effective competition.

In summary, Equations 4.1 through 4.6 depict the aggregative structure of the fresh and processed potato buyers. Implicit to the model is that potato growers are basically competitive as well as are the buyers of potatoes once they are processed or packaged for fresh shipment. The model attempts to capture the structure at the processor and handler level primarily because this is the point where major pricing and utilization decisions are made.

Equilibrium for the total potato industry cannot be evaluated in the long run without directly accounting for the structural changes as expressed with Equations 4.1 through 4.6. In the next section, the linkage of the structure with supply and demand relationships is again considered.

The Market Equilibrium Sector

As specified in Table 4.1, equation 4.7 is a direct measure of supply or production. Equations 4.8 and 4.9 are demand equations for fresh and processed potatoes respectively. Equations 4.10, 4.11, and 4.12 are price equations characterizing the retail price of fresh, the retail price of processed and the wholesale price of processed potatoes respectively. The farm price of fresh potatoes is estimated in equation 4.13. Equation 4.14 estimates the effect of the research and promotion tax on potatoes; tax revenues are generated as a direct function of the two demand equations specified in equations 4.8 and 4.9. The spread between the retail and farm price of potatoes is estimated in equation 4.15. Finally, a market clearing identity which assures utilization of all potatoes is specified in equation 4.16. The discussion of each equation attempts to further clarify linkages between the structural and equilibrium sectors.

Production of Raw Potatoes

Potato production has shown considerable variation during the 1960-81 period of this study. As production fluctuated, prices at the farm level fluctuated even more, almost invariably in the opposite direction. Equation 4.7 below is specified to explain these production changes.

(4.7) QRP = f (FPRL, QRPL, PS, TR, RS).

Potato producers are expected to vary their production in accordance to lagged potato prices, lagged potato production, lagged price of sugar beets, technological change and risk.

Potato producers are hypothesized to make production decisions based on prices in the previous year (FPRL). Increases (decreases) in FPRL are projected to increase (decrease) QRP. Stated differently, supply response is expected to be directly related to the average price of the previous season. The current farm price of potatoes is not considered a relevant variable because production decisions are generally made before it is known.

Because of tremendous price effects resulting from small production changes, producers are expected to consider QRPL in planning current production. As QRPL increases, QRP is expected to decrease because producers anticipate depressed prices in the current period.

While different commodities are grown as substitutes for potatoes in various regions of the U.S., it is hypothesized that one major commodity substitute will capture the impact of these substitutes on potato production. This commodity, based on research conducted by

Estes (1979), is sugar beets. Estes found sugar beets to be the major potato substitute in the Pacific Northwest and Red River Valley where over 50 percent of all U.S. potatoes are grown. From our basic theory of the firm, PS is expected to have negative coefficient as production of a commodity should decrease as the price of its primary substitute increases (note that PS is lagged).

Potato production is expected to be positively impacted by technological improvements. Although we have no measure of technological improvements in potato production, observations on yields per planted acre suggest substantial improvements. As a proxy for these technological improvements, a trend variable (TB) is specified.

Notwithstanding technological improvements, potato producers are continually confronted with risk (RS), both yield and price. The effect of risk is to reduce output beyond that which would occur in the absence of risk (Sandmo, 1971). In this study, RS is defined as the coefficient of variation in monthly potato prices. Price variance or risk should have increased for potatoes as technological improvements increased yields in the face of low demand elasticities. If producers are risk averse as is assumed in this study, potato production should be inversely impacted by RS.

Utilization of Potatoes for Fresh Consumption

Fresh potato consumption has declined considerably during the period of this study. Declining consumption has been registered on both per capita and absolute levels. Factors that will explain these changing consumption patterns are believed to be identified in equation 4.8 below.

(4.8) UZF = f(RPF, RPP, RPT: PN, IN, WN, FF, TF, GC)

Retail prices as opposed to farm prices are specified to impact the demand for fresh potatoes because these are the ones influencing purchasing decisions of consumers. The retail price of fresh potatoes (RPF) captures the direct response of quantity demand to price changes; by contrast, the retail price of processed potatoes (RPP) captures the indirect response. From our basic theory of demand, RPF is expected to have a negative coefficient; RPP should have a positive coefficient since processed potatoes are believed to be a close substitute for fresh ones.

The demand for fresh potatoes is expected to be influenced by the research and promotion tax (RPT) as revenues collected from this tax are used to advertise and promote potatoes. According to a recent report, several supermarket chains have increased their potato sales by as much as 40 percent since the merchandising promotion program began in 1974 (McClure, 1981). This datum suggests that consumers are susceptible to advertising and therefore a positive partial derivative is expected for RPT. From Table 4.1, it should be noted that tax revenues increase as the demand for both fresh and processed potatoes increases; this in turn makes more funds available for promoting potatoes and stimulating additional onsumption.

Several exogenous variables also are hypothesized to impact UZF. The importance of population (PN) and income (IN) follows directly from demand theory. No empirical estimates exist on the significance of PN for potato consumption because this variable has been used most often to convert other variables to a per capita basis. However, as the per capita consumption of fresh potatoes declined continually during the 1950-80 period, population growth did provide some stimulus to market expansion. On balance, then, one may hypothesize a positive coefficient for PN.

Empirical estimates do exist on the significance of IN to UZF. An income elasticity of demand of .11 was estimated by Estes (1979). Beilock (1981) found and income elasticity of demand of 1.79 for the combination of fresh potatoes and chips. Earlier studies by Shuffett (1954) and Hee (1967) reported income elasticities for fresh potatoes which ranged from .30 to .45. These studies, save Beilock's, suggest limited increases in UZF as income increases.

An increase of women in the labor force (WN) is expected to have a negative effect on UZF. This result is expected because households supposedly switch from fresh to processed potatoes as less time becomes available for meal preparation. As the ratio of fast-food sales to total away-from-home food sales (FF) increases, suggesting a rising percentage in sales of processed to fresh potatoes, one would expect UZF to be negatively impacted. Total away-from-home sales (TF) should have a positive impact on UZF since a larger proportion of these sales are at non fast-food establishments where fresh potatoes supposedly are in greater demand than processed.

The final variable in this equation, produce sales through retail grocery stores (GC), is expected to have a positive coefficient because a large percentage of produce sales consists of potatoes (McClure, p. 20). Furthermore, by purchasing more and more of their food products through retail grocery stores, consumers develop consistent purchasing habits which tend to be inflexible to price changes.

Utilization of Potatoes for Processing

Rapid expansion in demand for processed potato products is a dramatic economic development in the potato industry. This expansion has had repercussions on the number and size of potato processors and raw potato producers. Moreover, the spatial distribution of processors and raw potato producers also has undergone significant changes. Of course, the relevant issue here is the identification of those factors that explain changes in demand for processed potatoes. To this end, equation 4.9 below is specified.

(4.9) UZP = f(ASR, RPF, RPP, RPT: PN, IN, WN, FF, NF,
GC ASRL)

The demand for processed potatoes (UZP) is believed to be influenced by the same variables influencing UZF and the additional variables, current and lagged advertising. Processed potatoes, unlike fresh potatoes, usually are highly differentiated and this differentiation is often made known to consumers through advertising. An examination of advertising expenditures to market shares of such firms as Frito-Lay and Ore-Ida would suggest that advertising in the potato industry is effective in influencing consumers' purchasing decisions. Both ASR and ASRL are therefore expected to have positive coefficients.

The effects of retail prices on UZP are analogous to those on UZF. The retail price of processed potatoes (RPP) is expected to have a negative impact on UZP while RPF is expected to have a positive impact. Also by analogy to the previous equation, the effect of RPT is expected to be positive. Although promotion from RPT does not have the product differentiation emphasis as that promotion of processors, its effects are believed to be demand enhancing.

All the exogenous variables in this equation, save for GC, are expected to have demand enhancing effects. While there is likely to be high correlation among population (PN), income (IN), women in the labor force (WN), total away-from-home food sales (TF), produce sales through retail grocery stores (GC), and the ratio of fast-food sales to total away-from-home food sales (FF), this is an empirical problem that does not negate the theoretical underpinning of these variables.

The importance of PN in this equation stems from the simple fact that growth represents more potential consumers of processed products. Income is considered important not only because it represents the purchasing power of consumers for all products, but also because it characterizes a special relationship between consumption of processed potatoes and food consumption at away-from-home food establishments. During burgeoning economic times and therefore rising incomes, virtually all consumers increase their away-from-home food consumption. During worsening economic times and falling incomes, diners of upscale or fine restaurants 'trade down' and often frequent fast-food establishments (Ashton, 1980). Since these establishments serve larger proportions of processed potatoes, especially frozen french fries, the sale of processed potatoes becomes partly immune to income changes.

The variable WN is believed to be important in this equation as it reflects a demand for convenience which is a characteristic of processed potatoes. As WN increases, processed potatoes not only become more convenient for in-home consumption, but consumption of these products at away-from-home establishments also appear to be positively impacted. This stems partly from the apparent high correlation between increases of women in the labor force and increases of single parent households. The repercussion of this relationship on UZP results from the preference function of singles for dining in fast-food establishments where processed potatoes constitute a significant proportion of sales (Restaurant Business, 1982).

The expected significance of the variable FF stems from the large quantities of processed potatoes flowing through fast-food establishments. Frozen french fries, for example, are estimated to constitute 20 percent of fast-food sales (Cox, 1982). Given the past and continued growth of fast-food sales, FF is expected to have a positive and significant effect on UZP.

A number of socioeconomic changes in the U.S. economy together with marketing innovations at fast-food establishments would suggest that FF is likely to have a continued and significant impact on UZP. Socioeconomic changes which supposedly favor FF are declining household sizes, growing percentage of working women, and an increasing percentage of the 25 to 44 age group which dines out frequently. Marketing innovations initiated by fast-food establishments include menu diversity and moderate price increases over all selections. Menu diversity serves to attract both breakfast and dinner diners while moderate price increases help maintain those customers who would be turned away from large price increases on selected items.

Total away-from-home food sales (TF) are expected to positively impact UZP, but this impact is likely to be less significant than that of FF. That is, the rate of change of TF has been less rapid than that of FF. Besides, TF represent less concentrated sales of processed potatoes.

Produce sales through retail grocery stores (GC) have no predictable effect on UZP. Since potatoes constitute the largest percentage of produce sales, increases in GC should have a positive impact on UZF as consumers are predicted to develop consistent purchasing habits that are somewhat inflexible to price changes. The impact of GC on UZP is dependent on the relationship between fresh and processed potato consumption. A negative coefficient should result if the two commodities are substitutes, while a positive coefficient should result from complementarity in demand.

Retail Price of Fresh Potatoes

For a relatively unprocessed commodity like fresh potatoes, a high degree of correlation between changes in farm and retail prices should exist. A popular view among economists is that high price correlation is likely to exist only when farm prices are rising. Falling prices at the farm and wholesale levels, it is contended, are not likely to be passed on to consumers. Studies by Ward (1982) and the Council on Wage and Price Stability (1976) are not supportive of this view. In fact, Ward (1982) found price decreases at the wholesale level to be passed through at the retail level more readily than price increases.

Because of the anticipated correlation between farm and retail prices, the retail price of fresh potatoes (RPF) is hypothesized to be determined from the farm price (FPR) and marketing cost (MC). For estimating purposes, this equation (4.10) has been defined as an identity with estimation of its parameters deferred to equation 4.15. The variable SPR is simply the difference between RPF and FPR; this difference is estimated as a function of MC.

(4.10) $RPF = FPR + SPR$.

Retail Price of Processed Potatoes

Because of extensive product transformations, the retail price of processed potatoes (RPP), unlike that of RPF, is not expected to bear any close relationship to FPR. However, the wholesale price of processed potatoes (WPP), reflecting the marketing costs of product transformations, is expected to bear a close relationship to RPP. The retail price of processed potatoes is therefore specified as a function of WPP and TR, a trend variable. This trend variable is intended to capture what is believed to be changes in the ratio of retail to wholesalers prices.

(4.11) $RPP = f(WPP: TR)$

One reason the retail-wholesale price relationship is estimated to have changed is that concentration among retailers is believed to have changed. Retailers, acquiring increased market power, are more likely to increase margins between wholesale and retail prices.

Wholesale Price of Processed Potatoes

It is hypothesized that the wholesale price of potatoes equals the farm price plus the margin of the difference between the farm and wholesale price (PCM). This last component is estimated by equation 4.3. Because of some built in price stability, such as processors' purchase of raw potatoes through fixed contract prices, WPP is expected to show less variability than FPR.

(4.12) WPP = FPR + PCM

Farm Price of Raw Potatoes

Potatoes are a commodity which are produced and harvested all year long. The bulk of production, roughly 85 percent, is harvested during late summer and fall (Beilock, 1981). Thus, prices from the beginning of the year until fall harvest are a reflection primarily of the harvest of the previous year. Once the fall QRP is known or harvested, FPR is likely to be greatly impacted. Equation 4.13 is therefore specified as a function of QRP and QRPL.

(4.13) FPR = f(QRP: QRPL)

Both the farm price and production of potatoes have shown considerable variation during the 1960-81 period of this study. The absolute percentage change in price from year-to-year ranged from a low of 0 in 1969 to a high of 96.6 in 1964. Percentage changes in production ranged from a low of .7 in 1977 to a high of 20.7 in 1965 (Table 1.3). A common belief among potato marketing specialists is that much of this variability in FPR has been diminished as a result of contract purchases by processors. Although data are unavailable on the extent to which contracts are used, the ratio of percentage changes in price to percentage changes in production for the 1960-81 data period does not support the reduction in FPR hypothesis. Thus, the equation is believed to be correctly specified.

Research and Promotion Tax

The Potato Research and Promotion Act, enacted and approved in 1971, stipulates a mandatory withholding of one cent per hundredweight on potatoes used for food and seed. This collected revenue is then used for research, promotion, development, and advertising of fresh and processed potatoes. The ultimate objective of the tax is to increase potato utilization in both domestic and foreign markets.

Since potatoes for food consist of those going into fresh and processed uses, this equation is specified as a function of UZF and UZP.

$$(4.14) \quad RPT = .01\ UZF + .01\ UZP$$

Seed potatoes are excluded from this equation because they contribute a relative insignificant proportion of total tax revenues, less than 10 percent. Besides, given the difficulty of 100 percent collection, it is anticipated that this equation will generate revenues that closely approximate actual collection.

Spread Between Retail and Farm Price

This equation is defined as a function solely of marketing cost. Most potato marketing is done by specialized firms save for some limited washing, sorting and packing by a few producers (Summers and Drury, 1971). With marketing being a specialized operation, marketing cost is then logically an exogenous variable.

(4.15) $SPR = f(MC)$

The extent to which marketing costs can be passed on to consumers depends upon, among other things, the demand elasticity for potatoes, all cross-price elasticities, the income elasticity of demand for potatoes, and the relative importance of potatoes in consumers' diet. A recent study suggests that producers consider fresh potatoes to be of great importance in consumers diet and, as a result, retailers purposely add a high mark-up to them (Potato Marketing Team, 1972). These mark-ups, according to producers, stifle demand for fresh potatoes and therefore reduce their potential revenues.

Utilization of Total Production

A balancing equation is specified in equation 4.16 to assure utilization of total production. Total production is estimated in equation 4.7. Of this production, over 80 percent is invariably used for food. The remaining potatoes are diverted to livestock feed and seed, or lost to shrinkage. These uses are captured in utilization of other potatoes (UZO).

(4.16) $QRP = UZF + UZP + UZO$

A glance at Table 4.1 reveals that UZO is estimated as the residual of total utilization. This suggests that UZO, while not exactly fixed, varies only to the extent that the sum of UZF and UZP changes. It should be noted that exports are part of this total utilization. Imports are not included because they are of such limited quantity that their inclusion would most likely have little influence on the empirical results.

CHAPTER V
ECONOMETRIC MODELLING OF THE POTATO SUBSECTOR

Multicollinearity

Econometric studies which utilize time-series data typically contain exogenous variables which are highly interrelated. This study is no exception. In fact, not only are many of the exogenous variables highly correlated, but many endogenous variables are similarly correlated as would be expected. Such correlation presents difficult estimation problems. Various econometric methods for measuring the impacts of individual variables have been devised to compensate for the presence of high correlation; such correlation is known in econometric literature as multicollinearity.

Strong interrelationships among independent variables essentially make it difficult to disentangle their separate effects on the dependent variable (Maddala, 1977). When normal econometric estimating procedures are used without accounting for the presence of multicollinearity, estimates of the regression coefficients are generally unstable, nonsignificant, and may have algebraic signs that differ from theoretical expectations (Chatterjee and Price, 1977). Instability of regression coefficients may be discerned by observing large changes in the magnitude of these coefficients when a variable is added or deleted, or a data point is altered or dropped. The nonsignificance of variables are most frequently verified by their associated large standard errors.

Before estimating an econometric model which contains variables that one may suspect are highly correlated, several tests for the presence of multicollinearity are often applied. If multicollinearity is verified, corrective measures are warranted before undertaking the estimating procedures. In the present study, even the simplest test, simple correlation coefficients, verified the presence of multicollinearity. Correlation coefficients among both exogenous and endogenous variables frequently approached .9 and above. After considering the various corrective methods, principal components were used.

Before discussing principal components, a short discourse on other available methods for handling multicollinearity seems appropriate. These methods are (1) dropping variables, (2) ridge regression, (3) using extraneous estimates, (4) using ratios of first differences and (5) getting more data (Maddala, 1977). The author suggests that variables may be dropped from a model when, although theoretically justified, they are highly correlated with other variables but unimportant to the researcher. In the present study, few if any variables met this criterion. The ridge regression method suggests increasing the diagonal elements of the (X'X) matrix by very small numbers until the parameter estimates are stable (Hoerl and Kennard, 1970). Because this method essentially alters the data, it was considered inappropriate for this study.

The suggested method of using extraneous estimates appears most appropriate for simple models for which estimates of one or two variables may be derived from cross-sectional as opposed to time-series data. In the present model, too many of the variables are interrelated to consider compiling cross-sectional data. Besides, no cross-sectional data exist for a single industry. Using ratios or first differences is another suggested method for handling multicollinearity; however when either of these procedures is used, other econometric problems are introduced in the process of solving multicollinearity (Maddala, 1977). In the present study, no common trend exists to suggest the applicability of this method. Finally, the suggestion of getting more data is clearly not applicable to the present study since the only available data are of the same type, that is, annual.

In discussing solutions to multicollinearity, Intriligator (1978) suggests that a legitimate approach is simply to recognize its presence but not change the model or the data. That is, the model should not be respecified nor should additional data be collected. The principal component method provides a solution to an otherwise unsolvable problem of multicollinearity by transforming the data; that is, new variables are created as mixtures of the original data. This method involves the formation of new variables, principal components, as linear functions of the exogenous variables; the dependent variable(s) is (are) then regressed on the principal components, or a subset of the principal components, and the coefficients of the exogenous variables are derived from the regression coefficients on the principal components. A thorough discussion of this method follows.

Principal Components

Principal components may be defined as a set of orthogonal vectors which are derived as linear functions of other correlated variables. The original variables are most often standardized before components are derived because components are not independent of the scales in which the original variables are measured (Kendall, 1957). A variable is standardized by subtracting its mean from each observation and dividing by the standard deviation of the observations (Chatterjee and Price, 1977). The discussion which follows is predicated on the assumption of standardized variables.

Let X be the matrix defined below with n observation and k variables. One principal component approach is to ascertain the number of independent pieces of information among these k variables. One may have some a priori information, simple correlation coefficients, for example, suggesting that it is less than k. Or, theoretical reasoning may lead one to suspect that it is less than k. In any

$$X = \begin{bmatrix} x_{11} & x_{21} & \cdot & \cdot & \cdot & x_{k-1,1} & x_{k1} \\ x_{12} & x_{22} & \cdot & \cdot & \cdot & x_{k-2,1} & x_{k2} \\ \cdot & \cdot & & & & \cdot & \cdot \\ \cdot & \cdot & & & & \cdot & \cdot \\ \cdot & \cdot & & & & \cdot & \cdot \\ x_{1,n-1} & x_{2,n-1} & \cdot & \cdot & \cdot & x_{k-1,n-1} & x_{k,n-1} \\ x_{1n} & x_{2n} & \cdot & \cdot & \cdot & x_{k-1,n} & x_{kn} \end{bmatrix}$$

event, the derivation of principal components from the X matrix will clearly establish the amount of statistical independence among the variables.

Let p_1 be the first principal component derived from the X matrix as

(5.1) $p_1 = a_{11} x_{1t} + a_{21} x_{2t} + \cdot \cdot \cdot + a_{k1} x_{kt}$ $t=1,...,n$

In matrix notation,

(5.2) $p_1 = Xa_1$

where p_1 is a n-element vector, X a n x k matrix and a_1 a k-element vector. The sum of squares of p_1 is

(5.3) $p_1' p_1 = a_1' X' X a_1$

In deriving p_1, a_1 is chosen such that $p_1' p_1$ is maximized. This objective requires placing some constraints on a_1 since $p_1' p$ can be increased indefinitely. To this end, a_1 is normalized such that

(5.4) $a_1' a_1 = 1$

Now equation (5.3) can be maximized subject to (5.4).

Defining the Lagrangean function

$$(5.5)\quad Z = a_1' X'Xa + \lambda_1(1 - a_1' a\ )$$

where λ_1 is an undetermined Lagrange multiplier, this function may be solved as

$$(5.6)\quad \frac{\partial Z}{\partial a_1} = 2X'Xa_1 - 2\lambda_1 a_1$$

Solving this equation by setting $\frac{\partial Z}{\partial a_1} = 0$, results in

$$(5.7)\quad (X'X)\ a_1 = \lambda_1 a_1$$

Now the characteristic vector a_1 are the weights associated with the X variables to derive the characteristic root λ_1. In the typical characteristic value problem, a_1 and λ_1 are alternatively referred to as eigenvector and eigenvalue or latent vector and latent value.

To show that λ_1 is indeed the largest latent root of $(X'X)$, premultiply (5.7) by a_1'. Using (5.3) and (5.4), it is readily seen that

$$(5.8)\quad p_1'p_1 = \lambda_1 a_1'a_1 = \lambda_1 .$$

Since a_1 was chosen to maximize $p_1'p_1$ and $p_1'\ p_1$ equals λ_1, then λ_1 has to be the largest characteristic root of $X'X$.

To derive the second characteristic vector and root of $X'X$, define $p_2 = Xa_2$. To assure maximization of p_2 with no correlation with p_1, this derivation requires the additional constraint that $a_1'a_2 = 0$. This constraint follows by setting up the Lagrangean function

$$(5.9) \quad Z = a_2'X'Xa_2 + \lambda_2(1 - a_2'a_2) - wa_1'a_2$$

where both λ_2 and w are Lagrange multipliers. Differentiating (5.9) with respect to a_2 yields

$$(5.10) \quad \frac{\partial z}{\partial a_2} = 2X'Xa_2 - 2\lambda_2 a_2 - wa_1$$

Through simple algebraic manipulations of (5.10) used in conjunction with (5.7), it can be shown that w must equal zero. Thus the solution to (5.10) is

$$(5.11) \quad X'Xa_2 = \lambda_2 a_2$$

Using the same analogy as applicable to (5.8), it can be shown that λ_2 has to be the second largest characteristic root of $X'X$. Latent vectors and roots can be similarly derived for the remaining k-2 variables.

Assuming all k principal components are derived, they together with all characteristic vectors and roots may be compactly shown in matrix form. Let

$$(5.12) \quad A = [a_1, a_2, \ldots \ldots a_k]$$

be the k x k matrix of characteristic vectors. The n x k matrix of principal components is therefore

$$(5.13) \quad P = X A$$

The k characteristic roots may be shown in matrix form as expressed with equation 5.14.

$$(5.14)\quad P\ P = A\ X\ XA = \begin{bmatrix} \lambda_1 & 0 & . & . & . & 0 & 0 \\ 0 & \lambda_2 & . & . & . & 0 & 0 \\ . & . & & & & . & . \\ . & . & & & & . & . \\ . & . & & & & . & . \\ 0 & 0 & . & . & . & 0 & 0 \\ 0 & 0 & . & . & . & 0 & \lambda_k \end{bmatrix}$$

Since the λ's have been derived such that $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_k$ and the sum of the λ's measures the total variations of the X's, then the proportion of the variable accounted for by any component, p_i, equals $\lambda_1 / \Sigma\lambda$. If any λ_i equals zero, there is perfect linear relationship among the original variables (Chatterjee and Price, 1977). Multicollinearity is often revealed when some λ_i is not only small relative to the other λ's but also near zero. In these instances, the principal components corresponding to the small λ's may be dropped, but this is not tantamount to dropping variables from the original data (Kendall, 1957). Estimated parameters from a subset of principal components are biased, but considerable gains are realized in the precision of these parameters. With this general discussion of principal components, we now turn to their application in simultaneous equations.

Principal Components in Simultaneous Equations

A search of the literature reveals that principal components have been used in simultaneous equations invariably to solve degrees of freedom problems rather than provide solutions to problems of multicollinearity. Researchers employing principal components to solve the first-mentioned problem include (Kloek and Mennes, 1960), (Amemiya, 1966) and (Klein, 1969). Since both multicollinearity and insufficient degrees of freedom lead to singularity or near singularity of the (X'X) matrix, the use of principal components to solve problems of multicollinearity should be analogous to that of solving problems of degrees of freedom. To this end, the discussion which follows draws on the aforementioned studies.

The system to be estimated, as indicated in Table 4.1, is

$$(5.15) \qquad \Gamma_{Yt} + \beta X_t + U_t = 0 \qquad t = 1, . . ., n$$

where Γ is a GxG matrix of coefficients of current endogenous variables, β is a G x K matrix of coefficients of predetermined variables, and Y_t , X_t and U_t are column vectors of G, K, and G elements, respectively. A single equation from this system may be written as

$$(5.16) \quad y = Y_1\Gamma + X_1\beta + u$$

where

y is the N x 1 vector of observations on the dependent variable,

Y is the N x g matrix of observations on the others endogenous variables included in the equation, is the $g \times 1$ vector of coefficients on the Y endogenous variables,

X is the $n \times k$ matrix of observations on the predetermined variables in the equation,

is the $k \times 1$ vector of coefficients on X,

is the $N \times 1$ vector of random errors.

Considerable degrees of freedom problems are experienced in the estimation of equation (5.16) using two-stage least-squares (2SLS) if the number of predetermined variables (K) equals or exceeds the number of sample observations (N). In large models, it is not uncommon to observe $K > N$ (Kloek and Mennes, 1960). Since $K > N$ implies a singular $(X' X)$ matrix and the resulting inability to estimate the reduced-form disturbances, Kloek and Mennes (1960) recommend the use of principal components to effectively reduce K. The number of predetermined variables (K) may be similarly reduced when there is multicollinearity among them (Klein, 1969).

Kloek and Mennes (1960) outlined four alternatives for determining principal components from the predetermined variables. Let $X = (X_1 \ X_2)$ represent the division of all predetermined variables (X) into those included (X_1) in the equation under study and those excluded (X_2). Then the alternatives suggested by Kloek and Mennes (1960) are (1) include the X_1 variables and the first m principal components (m also must be determined), (2) include the X_1 variables and the m principal components derived from the residuals of the regression of the X_2 variables on X_1, (3) include the X_1 variables and the m principal components which are least correlated with X_1, and (4) include m principal components from X which capture the maximum variance. Because the first three of these methods require calculation of a different set of principal components for each equation in a simultaneous system, the authors favor the last-mentioned method because of its practicality. As a variant of this method, Klein (1969) used 2SLS with four and eight principal components and concluded that 2SLS with four components performed better than (1) 2SLS with eight components, (2) ordinary least squares (OLS) and (3) full-information maximum likelihood (FIML) estimators.

Since a single set of principal components determined from all predetermined variables is most commonly used in research studies, the strengths and weaknesses of the other methods are not addressed (Kloek and Mennes, 1960). Even with a single set, the number of components, m, must still be determined.

Several criteria have been suggested for determining the optimal number of components (m). Kendall and Stuart (1966) suggest using a test on the equality of those latent roots that appear small in comparison to other roots. If such test shows equality of $(k - m)$ roots, $(m < k)$, then only the first m components corresponding to these m roots are retained. As a variant of this criterion, Pidot (1969) and Mittelhammer and Baritelle (1977) have suggested deleting components with small characteristic roots without testing the equality of these roots. Pidot (1969) also suggested the deletion of principal components based on t-values of the regression coefficients, components with nonsignificant t-values being deleted. Of the three methods, choosing components based on the size of characteristic roots appears most practical and therefore is adopted here.

Conceptually m should be inversely related to the degree of correlation among variables, since each component captures the maximum variation in the independent variables. However, the requirement for equation identification inevitably will influence m since it must be greater than or equal to the number of endogenous variables (G) appearing in the equation (Kloek and Mennes, 1960). Because the current study utilizes principal components on those predetermined and endogenous variables included in each equation, a more restrictive requirement could be used to determine m; namely, m must capture at least 90 percent of the total variation in the X_1 variables.

Principal Components in Present Study

Because the model specified in Table 4.1 to analyze the U.S. potato industry is based on well-developed underlying economic theory, all variables, despite strong interrelationships, are considered crucial to an understanding of changes occurring in the potato industry. Consequently, variables are not dropped or aggregated to get better or precise estimates of specified parameters. Instead principal components, linear combinations of the original variables, are derived and used in the estimation of those equations with extreme multicollinearity problems; these estimates are then used to derive the coefficients of the original variables.

A quick glance at the model specified in Table 4.1 reveals sixteen endogenous and twenty exogenous variables to analyze the U.S. potato industry. No equation includes more than four endogenous nor more than seven predetermined variables. Despite the limited number of variables per equation, simple correlation coefficients as well as other tests revealed severe multicollinearity among sets of endogenous, sets of exogenous, and combinations of endogenous and exogenous variables. A search of the literature revealed no studies that have dealt with collinearity among both endogenous and exogenous variables. However, a simple extension of the uses of principal components seems applicable to such a problem.

To facilitate our discussion, consider equation 4.4 from the system of equations specified in Table 4.1.

$$(5.17)\quad ASR = \Gamma_1\, CRP + \Gamma_2\, UZF + \Gamma_3\, UZP + \Pi_0 + \Pi_1\, GR + \Pi_2\, GD + \Pi_3\, PCML + U$$

The simple correlation coefficients on the variables in this equation are reproduced below in Table 5.1. Observation of the coefficients reveals that the variables in this equation are too highly correlated to obtain precise estimates of individual parameters. However, Chatterjee and Price (1977) have shown that it is possible to obtain estimates

Table 5.1--Correlation Coefficients

	CRP	UZF	UZP	GR	GD	PCML
CRP	1.0000					
UZF	-.9319	1.0000				
UZP	.8537	-.8876	1.0000			
GR	.9159	-.9624	.9476	1.0000		
GD	-.8890	.9069	-.9145	-.9502	1.0000	
PCML	-.8307	.8240	-.9079	-.8332	.7962	1.0000

for linear combinations of the exogenous variables for such equation. Following the methodology outlined by Chatterjee and Price (1977), linear combinations of the endogenous and exogenous variables are used to calculate principal components. Parameter estimates are obtained on these orthogonal principal components and then these estimates are used to derive the parameter estimates for the original variables. Of course, means of maintaing the simultaneity of the system with principal component estimation are also developed.

Given a simultaneous system in which the endogenous and predetermined variables of specific equations are treated, in essence, as single sets of predetermined variables when estimating principal components, the simultaneity of the system will vanish when each respective dependent variable is estimated on these components. Simultaneity can be maintained, however, if the portions of the components accounted for by the endogenous variables are specified as variables and these respective variables then constrain the system as identities. An example of the process follows.

Consider the advertising equation 5.17. Principal components are derived on the set of variables as though they are all predetermined. Only two components are used since they capture 95 percent of the total variability (Table C.2). The weights (eigenvectors) used to derive these components, together with the mean and standard deviation of each variable, are reproduced below.

Table 5.2--Eigenvectors

Variable	Comp1	Comp2	Mean	St. Dev.
CNP	.4059	.2337	64.61	4.16
UZF	-.4130	-.2907	62.76	12.62
UZP	.4126	-.2932	59.95	15.26
GR	.4203	.2204	55.85	17.07
GD	-.4089	-.3004	.7753	.0399
PCML	-.3878	.7976	6.032	1.692

Estimating equation 5.17 on the two components, Comp1 and Comp2, would be tantamount to estimating a single equation that had no relationship to the other fifteen of the system. The components were therefore separated into portions which were due to (1) endogenous and (2) predetermined variables. These respective variables were then identified as part of the data set and the portion represented by the endogenous variables further denoted as identities constraining the system (Table C.3). These identities, in effect, maintained the simultaneity of the system.

The principal component variables resulting from the above endogenous variables are

$$\text{BARD1} = .4059/4.16\ (\text{CRP} - 64.61) - .4130/12.62\ (\text{UZF} - 62.76) + .4126/15.26\ (\text{UZP} - 59.95) \tag{5.18}$$

$$\text{BARD2} = .2337/4.16\ (\text{CRP} - 64.61) - .2907/12.62\ (\text{UZF} - 62.76) - .2932/15.26\ (\text{UZP} - 59.95) \tag{5.19}$$

The remaining portions of these components attributed to the predetermined variable may be similarly written as

$$\text{CARD1} = .4203/17.07\ (\text{GR} - 55.85) - .4089/.0399\ (\text{GD} - .7753) - .3878/1.692\ (\text{PCML} - 6.032) \tag{5.20}$$

$$\text{CARD2} = .2204/17.07\ (\text{GR} - 55.85) - .3004/.0399\ (\text{GD} - .7753) + .7976/1.692\ (\text{PCML} - 6.032) \tag{5.21}$$

It should be obvious from the derivations that

$$\text{COMP}_i = \text{BARD}_i + \text{CARD}_i \tag{5.22}$$

The means and standard derivations enter the principal components 5.18 - 5.21 because each variable is standardized in the process of deriving components. The endogenous portions of these components are further specified in the equation system as identities; for estimating purposes, all identities are specified as linear combinations of the variables. Thus, the first identity is written

$$\text{Identity BARD1} = .0975\ \text{CRP} - .0327\ \text{UZF} + .0270\ \text{UZP} - 5.8679 \tag{5.23}$$

Equation 5.17 is estimated as

$$(5.24)\ ASR = \Gamma_1 BARD1 + \Gamma_2 BARD2 + \Pi_0 + \Pi_1 CARD1 + \Pi_2 CARD2 + u$$

with the restrictions that $\Gamma_1 - \Pi_1$ and $\Gamma_2 - \Pi_2$ equal zero. These restrictions mean that the equation is estimated as a function of $COMP_i$ while simultaneously allowing the system to recognize the interrelationships among the endogenous variables as specified in the identities.

Estimating techniques identical to those used in equation 5.17 were used for eight additional equations because of the presence of multicollinearity. Additionally, multicollinearity among the set of predetermined variables also required the derivation of principal components. Five components were used as these captured 95 percent of the total variation (Table C.2). Each endogenous variable was estimated as a function of these five components in the first-stage regressions. These estimated endogenous variables were, in turn, used in the second stage regressions. Third-stage regressions were then derived on the complete system of equations (Table C.4). The resulting parameters and statistical properties of these parameters are discussed in Chapter VI.

CHAPTER VI
OPERATIONALIZING THE POTATO MODEL

Introduction

The purpose of this chapter is to report estimated empirical results for both the structural and market equilibrium sectors of the U.S. potato industry as set forth in Table 4.1. First, the procedures used to derive parameter estimates from principal component parameters will be reported. Second, parameter estimates for the six structural equations will be reported and the statistical significance of these parameters evaluated. Estimated structural changes in the potato industry will be analyzed from both empirical and theoretical perspectives; discrepancies between theoretical expectations and estimated results will be underscored.

Following the report of the structural equations will be a report of the market equilibrium equations and their associated parameter estimates. The statistical significance of these parameters together with the procedures used to determine this significance will be reported. These parameter estimates then will be evaluated for their conformity to economic theory; dynamics among structural and market equilibrium parameters will be noted and highlighted. Finally, a summary of structural and market equilibrium results will be reported.

Parameter Estimates and Their Properties

As discussed in the preceding chapter, principal components are used to estimate equations with considerable or extreme multicollinearity problems. Because of multicollinearity, all six structural equations are estimated with principal components. Parameter estimates of the original variables in each structural equation are then derived from the estimated principal component parameters.

Since principal components are linear combinations of original variables, the parameter estimates for the principal components can be decomposed into their respective estimates for the original variables. To understand the method of derivation, consider equation 4.1 from the system of equations in Table 4.1.

$$(6.1) \quad NPP = T_1\,PCM + T_2\,UCA + \eta_0 + \eta_1\,MS + \eta_2\,GR + \eta_3\,GD + \eta_4\,CT + \eta_5\,PCML + \eta_6\,UZPL + U.$$

This equation, estimating the number of potato processing plants, is a function of two endogenous and six predetermined variables. Considering all variables as exogenous (as explained in Chapter V) for the purpose of deriving principal components, a total of eight components are derived. Only the first two of these eight components are used in the regression as 90 percent of the total variability among these variables are captured by these two components (Table C.2).

The two components may be written as

$$
\begin{aligned}
(6.2)\quad \text{Comp1} = {} & -.33301\ \text{PCM} + .35579\ \text{UCA} + .38058\ \text{MS} \\
& + .38095\ \text{GR} - .37227\ \text{GD} + .28603\ \text{CT} \\
& - .34123\ \text{PCML} + .36836\ \text{UZPL} \\
\text{Comp2} = {} & .44814\ \text{PCM} + .03583\ \text{UCA} + .13285\ \text{MS} \\
& - .03625\ \text{GR} - .09860\ \text{GD} + .79737\ \text{CT} \\
& + .34015\ \text{PCML} - .13297\ \text{UZPL}
\end{aligned}
$$

Equation 6.1 is estimated on the two components as

$$(6.3)\quad \text{NPP} = \beta_0 + \beta_1\,\text{Comp1} + \beta_2\,\text{Comp2} + U$$

The estimates for these parameters are $\beta_0 = 352.701$, $\beta_1 = -33.003$ and $\beta_2 = -23.199$. To derive the coefficients in equation (6.1) from the principal component parameters, the weights on each respective variable are multiplied times both β_1 and β_2 and then the resulting sums divided by the standard deviations of the corresponding variables. For example,

$$(6.4)\quad T_1 = -.33301(-33.003) + .44814(-23.199)\ \ /1.5617$$

where 1.5617 is the standard deviation of PCM. Parameter estimates for the remaining variables of equation (6.1) and the remaining equations of Table 4.1 are similarly derived.

The preceding example was simplified for the purpose of clarity. More generally, equation 6.1 was estimated on the two principal components as noted in equation 6.3, but these components were separated into their endogenous and exogenous parts. Thus, two additional Beta coefficients resulted from the estimation of equation 6.3. Specifically, the equation was estimated as

$$(6.5) \quad NPP = \eta_0 + T_1\, BARA1 + T_2\, BARA2 + \eta_1\, CARA1 + \eta_2\, CARA2$$

Table C.3 provides the estimating procedures for all equations estimated with principal components. Restrictions are placed on the T 's such that $(T_1 - \eta_1)$ and $(T_2 - \eta_2)$ equal zero. As a consequence, the derivations as described in the preceding example are mathematically correct, but the impact of restrictions on the Beta coefficients and their variances must now be recognized and highlighted. Recall that including the equations for the endogenous part of the principal components allows for all endogenous variables to be clearly identified throughout the system.

Consider the system of equations as specified in Table 4.1 and represented below in more general notations as

$$(6.6) \quad Y = Z\beta + U$$

where $Y = (Y_1 \ldots Y_G)$, $Z = (Y_G \;\; X_K)$, $\beta = (\Gamma_G \Pi_K)$ and $U = (U_1 \ldots U_G)$.

Zellner and Theil (1962) have shown that an alternative and efficient method of estimating the system of equations specified in (6.6) is to first premultiply it through by the matrix of observation on all the predetermined variables in the system and then estimate this alternative form by generalized least squares. Such multiplication leads to the following system

$$(6.7) \quad \Pi' y = \Pi' Z\beta + \Pi' U$$

where Π is the diagonal matrix of observation on all predetermined variables.

A set of restrictions imposed on this system of equations may be specified as

$$(6.8) \quad r = RB$$

where r is a Gx1 known vector and R is a GxK known matrix of restrictions on the elements of B. With these restrictions imposed on (6.7), it can be shown that the resulting restricted three-stage least-squares (3SLS) estimator is

$$(6.9) \quad \tilde{\beta} = \hat{\beta} + CR'(RCR')^{-1}(r - R\hat{\beta})$$

where $\hat{\beta}$ is the unrestricted (3SLS) estimator and equals

$$\hat{\beta} = \{Z'\Pi[\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\, \Pi'Z\}^{-1}\, Z'\Pi\, [\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\, \Pi'y$$

C is the first part of $\hat{\beta}$ enclosed by $\{\ \}^{-1}$, R and r are as previously defined. These restricted and unrestricted 3SLS estimates were derived respectively by Schmidt (1976, p. 243) and Goldberger (1964, p. 351).

From the estimates expressed in (6.9), it can be seen that the restricted estimator differs from the unrestricted one by the second expression on the right-hand side. In the present model where the β 's are derived from coefficients of principal components, the estimator in (6.9) becomes

$$(6.10)\quad \tilde{\beta} = \{W[\hat{\beta} + CR'(RCR')^{-1}(r - R\hat{\beta})]\}\ V^{-1}$$

where W is a diagonal matrix of weights or eigenvectors and V is a column vector of the standard deviations of the variables corresponding to the respective blocks of W. It should be noted that the division by V is necessary only because the original variables have been standardized in the derivation of principal components. To be accurate, the means also should be subtracted from the estimators expressed in (6.10). Since only the intercepts are affected by subtraction of means, and they are of minimum interest here, this step is excluded to avoid cluttering the expression.

While the $\tilde{\beta}$ estimator has been derived by other researchers, its variance properties have not been shown. The expression in (6.9) can be used for these derivations since the additional operations in (6.10) are relevant only to the final result. These derivations are included here because they are unavailable in other sources.

Using the restricted and unrestricted 3SLS estimators derived respectively by Schmidt (1976) and Goldberger (1964), it is shown that the variance of $\tilde{\beta}$ differs from the variance of $\hat{\beta}$ by the matrix $A = [I - CR'(RCR')^{-1} R]$. To derive this result, the unrestricted estimator is substituted into the appropriate parts of the restricted estimator and the appropriate algebraic and mathematical manipulations performed.

The variance of $\tilde{\beta}$ is derived as follows. Substituting the unrestricted estimator $\hat{\beta}$ and y into the first part of the restricted estimator $\tilde{\beta}$

$$(6.11) \quad \tilde{\beta} = \{Z'\Pi[\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\Pi'Z\}\, Z'\Pi[\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\, \Pi'(Z\beta + U) + CR'\,(RCR')^{-1}\,(r - R\hat{\beta})$$

This reduces to

$$(6.12) \quad \tilde{\beta} = \beta + C\{Z'\Pi[\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\Pi'\, U + CR'\,(RCR')^{-1}\,(r - R\hat{\beta})$$

Substituting $\hat{\beta}$ in the last part of (6.12) yields

$$(6.13) \quad \tilde{\beta} = \beta + C\,\{Z'\,[\,\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\,\Pi'\, U + CR'\,(RCR')^{-1}\, RCZ'\Pi[\Sigma^{-1}\,(X'X)^{-1}]\Pi'\, U$$

or simply

$$(6.14) \quad \tilde{\beta} = \beta + \{I - CR'\,(RCR')^{-1}\, R\, CZ'\,\Pi[\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\,\Pi'\, U$$

Let $A = I - CR'\,(RCR')^{-1}\, R$. Then the variance becomes

$$(6.15) \quad E(\tilde{\beta} - \beta)\,(\tilde{\beta} - \beta)' = E\{ACZ'\Pi\,[\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\Pi'UU'\,\Pi\,[\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\Pi'ZC'A'$$

Goldberger (1964, p. 350) has shown that $E(\Pi'UU'\Pi)$ equals $(\Sigma \otimes X'X)$. Using this value in (6.15) yields

$$(6.16) \quad \mathrm{Var}\,(\tilde{\beta}) = \{ACZ'\Pi[\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\,\Pi'ZC'A'\}$$

Substituting for C in (6.16) above yields

$$(6.17) \quad \mathrm{Var}\,(\tilde{\beta}) = A\{Z'\,\Pi[\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\,\Pi'Z\}^{-1}\, A'$$

Substituting for A in (6.17) and carrying out the algebraic operations, this variance simplifies to

$$(6.18)\quad \mathrm{Var}\,(\tilde{\beta}) = A\,\{Z'\,\Pi[\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\,\Pi'Z\}^{-1}, \text{ or simply AC.}$$

Goldberger (1964, p. 352) has shown that the C in (6.18) is the variance for the unrestricted 3SLS estimator. Thus, the variances for the two estimators differ by the matrix A. No general statements can be made about A since it is dependent upon the restrictions on the system of equations. Moreover, it would not be valid to estimate the variances of an unrestricted system and then compare them to those obtained from adding restrictions since the β's would also differ. The above derivations are intended only to show how variances of restricted 3SLS are determined once R is specified.

To reflect the use of principal components in the present model, the variance expression in (6.18) becomes

$$(6.19)\quad \mathrm{Var}\,(\tilde{\beta}) = W\,[A\{Z'\Pi[\hat{\Sigma}^{-1} \otimes (X'X)^{-1}]\,\Pi'Z\}^{-1}W$$

It should be noted that the β's in (6.19) have not been divided by V to correct for the scale factors as in (6.10). This is due to the equivalence of the t-values for scaled and unscaled β's when these values are derived from scaled β's and a scaled variance-covariance matrix (Chatterjee and Price, 1977). Thus the variance expression in (6.19) is reflective of the fact that the Statistical Analysis System

(SAS) package as used in the present study reports only the scaled variance-covariance matrix. The ultimate step of deriving t-values for β_i equals zero involves dividing the parameter estimates in (6.10) (less division by V) by their standard errors (square root of 6.19). Because of the size of the matrices involved and the relative efficiency of computers, the β's, standard errors, and t-values reported here are as derived from the SAS package.

Structural Equations Results

The three-stage least squares estimators conform well with a priori theoretical expectations, particularly in light of the number of parameters estimated. Of the thirty (30) estimated parameters for which economic theory provided insight and guidance as to expected signs, twenty-two (22) were signed as expected. Instances of sign divergence are explainable and appear to be related to the rapid structural changes occurring in the potato industry. Proxy variables may also be a factor in the divergence of signs.

Number of Processing Plants (NPP)

The first equation estimating the number of processing plants (NPP) performs unsatisfactorily in terms of apriori expectations. Three of the eight estimated parameters have signs which differ from theoretical hypotheses and a fourth parameter, Γ_{13}, although correctly signed, is statistically nonsignificant. All parameter estimates, except Γ_{13} though, are statistically significant. These parameter estimates, their standard errors, and t-ratios are shown in Table 6.1. The full model is shown in Table 6.3.

As the results in Table 6.1 show, NPP is unaffected by PCM. On the surface, this suggests that potato processors are not guided by profits when constructing or closing plants. A more subtle examination of the industry, however, reveals that processors simply cannot respond immediately to changing profit conditions but do adjust their plants accordingly after some time-lag. This adjustment process is revealed in the positive and significant coefficient for PCML. Another parameter with a sign that seems to represent the antithesis of economic theory is UCA. Unquestionably, as the utilization of capacity of an industry increases, a positive signal should be sent to entrepreneurs to adjust plants accordingly. The current parameter estimate for UCA indicates, however, that a one percent increase in UCA leads to a 1.4 unit decrease in NPP. Does this suggest irrational behavior on the part of potato processors? An examination of the industry, as discussed below, suggests a resounding no to this question.

At its inception and initial growth, the potato processing industry, particularly the chipping sector, was inundated by small processors (Snack Food Blue Book, 1976). As the industry matured and adopted many technological improvements, many smaller processors ceased production. With small operations and primarily local markets, many

Table 6.1--Parameters and Statistics for Structural Equations

NPP Equation 6.1

VARIABLE	NSTAD-B	STAD-B	STAD-ERR	T-RATIO
Intrc (Π_{10})	352.70	-	5.104	69.099
PCM (Γ_{13})	.38	.594	1.973	.301
UCA (Γ_{16})	-144.53	-12.574	.622	-20.215
MS (Π_{11})	-1.30	-15.643	.846	-18.489
GR ($\Pi_{1,17}$)	-.59	-11.732	.670	-17.500
GD ($\Pi_{1,14}$)	364.42	14.574	.750	19.430
CT (Π_{13})	-3.66	-27.939	3.366	-8.300
PCML (Π_{12})	1.99	3.371	1.550	2.173
UZPL ($\Pi_{1,18}$)	-.55	-9.073	.848	-10.692

CRP Equation 6.2

Intrc (Π_{20})	64.607	-	.288	223.606
NPP (Γ_{21})	-.007	-.670	.048	-13.684
ASR (Γ_{24})	272.668	.626	.104	5.973
MS (Π_{21})	.059	.710	.045	15.619
CK (Π_{25})	.146	.554	.103	5.384
CT (Π_{23})	.069	.530	.115	4.607
PCML (Π_{22})	-.393	-.666	.076	-8.751
ASRL ($\Pi_{2,20}$)	269.984	.650	.091	7.079

PCM Equation 6.3

Intrc (Π_{30})	5.840	-	.180	32.401
CRP (Γ_{32})	-.090	-.377	.051	-7.310
UCA (Γ_{36})	-2.192	-.190	.113	-1.687
PCML (Π_{32})	.475	.805	.146	5.490

ASR Equation 6.4

Intrc (Π_{40})	.0096	-	.000288	33.2112
CRP (Γ_{42})	.000047	.000197	.000109	1.8111
UZF (Γ_{48})	-.000013	-.000171	.000132	-1.2935
UZP (Γ_{49})	.000032	.000503	.000134	3.7520
GR ($\Pi_{4,17}$)	.000012	.000217	.000104	2.0749
GD (Π_{44})	-.004058	-.000162	.000136	-1.1919
PCML (Π_{42})	-.000455	-.000770	.000346	-2.2261

CCA Equation 6.5

Intrc (Π_{50})	.089202	-	.009248	9.6451
NPP (Γ_{51})	.000181	.015699	.002388	6.5724
UCA (Γ_{56})	-.171237	-.014897	.003426	-4.3473
PCML (Π_{52})	.008306	.014057	.006426	2.1873
CK (Π_{55})	-.003839	-.014506	.008070	-1.7797

Table 6.1--Continued

UCA Equation 6.6

VARIABLE	NSTAD-B	STAD-B	STAD-ERR	T-RATIO
Intrc (Π_{60})	.589443	-	.009724	60.6360
NPP (Γ_{61})	-.000265	-.023066	.002556	-9.0234
CCA (Γ_{65})	-.846003	-.054441	.012733	-4.2756
UZP (Γ_{69})	.000651	.009951	.004733	2.1023
PCML (Π_{62})	.001047	.001773	.008086	.2192

Note that each dependent variable and equation number correspond to those in Tables 4.1 and 6.3.

smaller processors utilized only a fraction of their total capacity because their production periods were limited to a few months per year. As these smaller firms ceased production, UCA for the industry increased. The current economic-market-structure theory pertaining to this issue suggests that UCA is related to demand conditions and, therefore, new capacity is added in response to these conditions (Sawhney and Sawhney, 1973). For the potato industry, many of the changes in UCA are due to technological factors rather than changing demand factors. That is, as smaller firms ceased production because of constraints prohibiting their adoption of technological improvements, UCA increased for the industries because of higher utilization rates of the remaining firms. Moreover, these remaining firms probably increased these rates as they produced more to compensate for the loss of production resulting from the exit of smaller firms.

As the efficient scale of production (MS) increases, NPP decreases as theoretically hypothesized. The parameter estimate suggests that a one unit increase in MS (1,000 pounds per hour) leads to a loss of 1.3 plants. To add some perspective to these numbers, a typical frozen potato processor currently produces 50,000 pounds of finished frozen potatoes per hour. This represents a ten-fold increase in production from the 5,000 pounds produced in 1960. The number of potato processing plants, during the 1960-82 data period, declined from 446 to 221. Thus, the parameter estimate suggests that smaller plants (firms) can become obsolete or inefficient from small changes in production rates.

Parameter estimates for both GR and UZPL have signs which contradict our economic hypotheses. The two parameters are similar in that GR represents a three period lag of UZP while UZPL represents a one period lag. The signs on these parameters raise the obvious question of the economics underlying a decline in the number of plants while the volume of processed potatoes continually increases. The answer is equally obvious. From its inception, the potato industry began with an non-equilibrium number of plants and firms. It appears now to be gradually moving toward an equilibrium number and size of firms. The industry has absorbed the increased production with fewer plants by significantly increasing the size of its plants. Perhaps a better variable to capture the relationship between plants and increased utilization of potatoes would have been total capacity of plants.

As potato production becomes more dispersed (GD), NPP increases. Given the significant decline in NPP over the data period, the parameter estimate for GD suggests that potato production has become more concentrated or less dispersed. The coefficient reveals that a one percent increase in GD leads to a 3.6 units decline in NPP. Conceptually, it is difficult to envision the magnitude or volume of potatoes involved in a one percent increase in GD since it represents a measure of dispersion or concentration as captured by the Herfindal index. Suffice it to say, though, that there have been tremendous shifts in production from the Northeast and Central states to the Pacific Northwest region (Figures 6.1 and 6.2).

Besides Π_{10}, the only remaining parameter yet to be discussed is that for transportation cost (CT). As explained in Chapter IV, economic theory provides no apriori guidance as to the expected sign of this parameter. As estimated here, a one unit increase in CT leads to a decrease of 3.7 units in NPP. This suggests that rising CT is not a significant factor in the optimal number and location of plants. Other factors, such as economies of scale in production and perhaps technological efficiencies, have undoubtedly had a greater influence on the optimal number of plants than CT. More drastic changes in CT than those registered during the data period could reverse the relationship between NPP and CT.

Concentration in Processed Potato Production (CRP)

The signs on all but one estimated parameters in this equation conform with our economic hypotheses. Additionally, all parameters are statistically significant at the .01 level. These parameter estimates, their standard errors, and t-ratios are shown in Table 6.1.

From the standardized parameters, it may be seen that MS has the greatest impact on CRP, in terms of absolute value. A one standard deviation change in minimum efficient

Peaks Depict Relative Production
Production in Eastern States high Relative to that in Western States

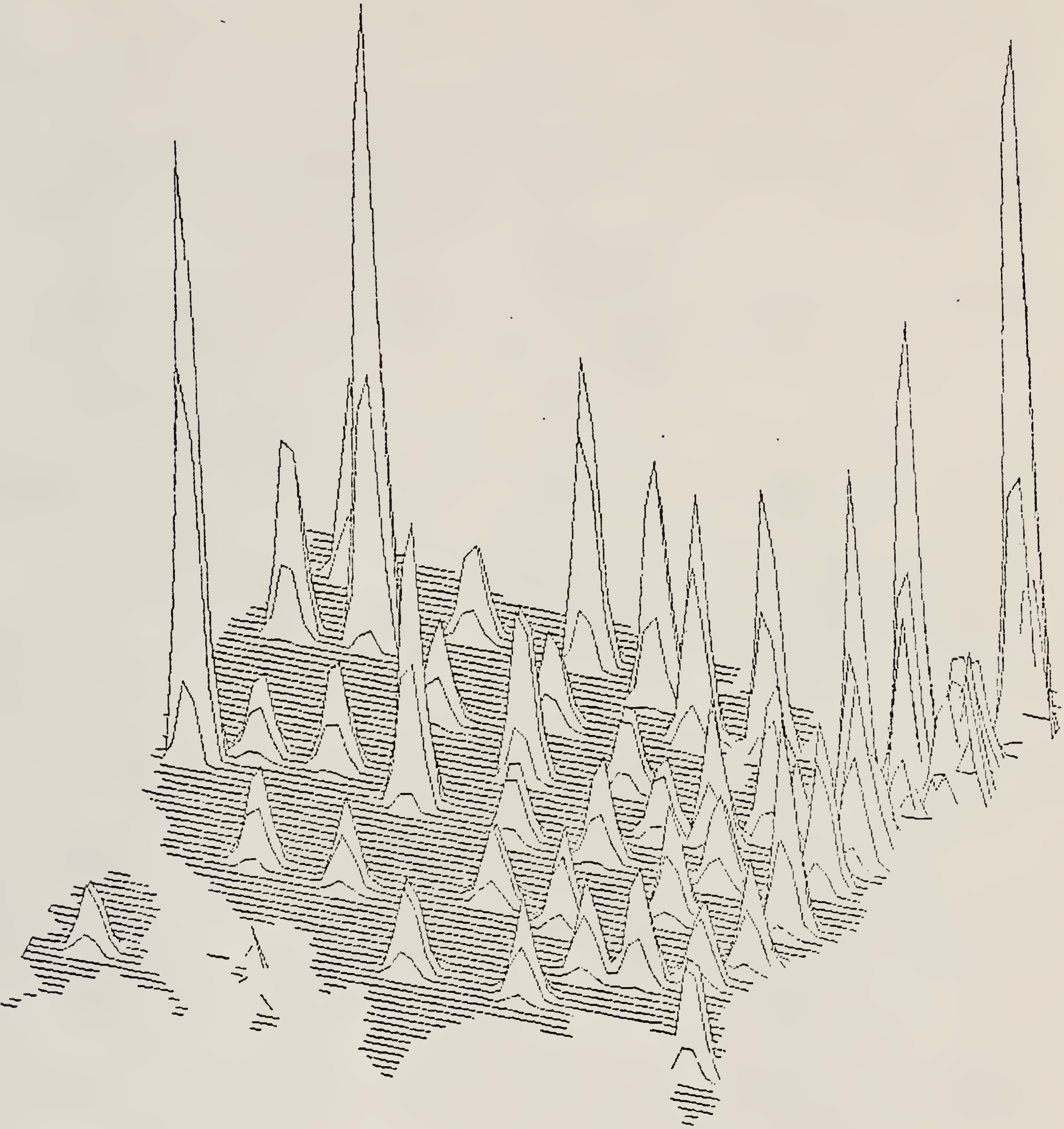
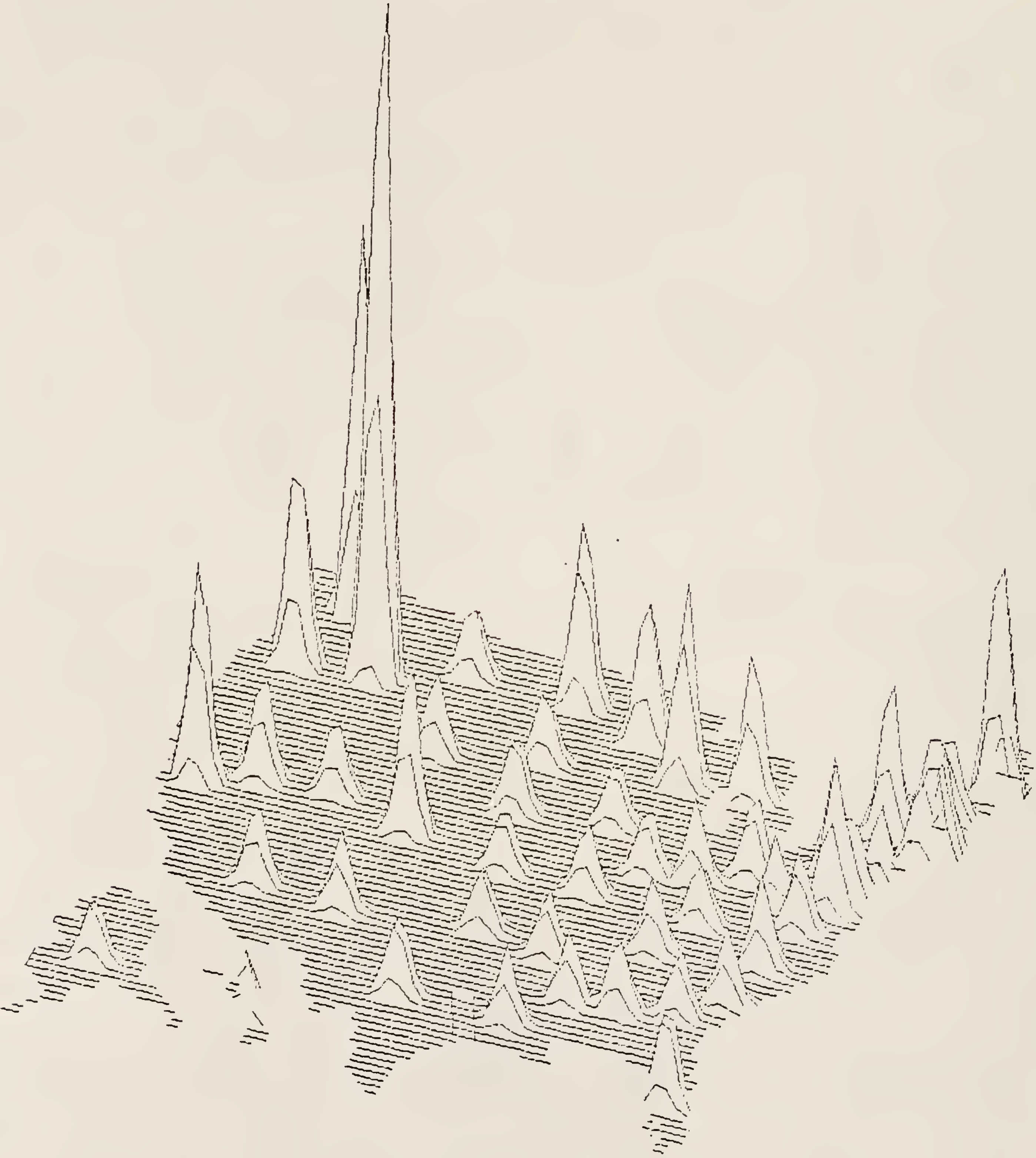


Figure 6.1. U.S. Potato Production by States, 1950



Peaks Depict Relative Production
Production in Eastern States low Relative to that in Western States

Figure 6.2. U.S. Potato Production by States, 1980

plant size (MS) leads to a .7 percent change in CRP--all regressors are standardized but the regressand is nonstandardized. Focusing our discussion on the nonstandardized coefficients, a one unit increase in NPP precipitates a .008 percent decrease in CRP. A one percent increase in both current and lagged advertising sales ratio (ASR) generates a 2.7 percent increase in CRP. Though the magnitudes of the effects of NPP, ASR and ASRL on CRP seem significantly different, when the units of measurements are accounted for, as reflected in the standardized parameters, the effects of the variables are virtually indistinguishable (absolute value effects).

One disappointing result of these estimated parameters is the failure to establish or confirm the expected positive relationship between concentration and profitability. Many researchers have tested this relationship and, for the most part, established or failed to disprove a positive relationship (Weiss and Siegfried, 1974). Unlike the present study, though, these positive relationships were established not for individual industries over time, but for a comparison of industries using cross-sectional data (Gabel, 1979). Positive relationships noted here may have resulted from the nature of the industries studied.

The parameter estimate for PCML indicates a decline in CRP of .4 percent for each unit increase in PCML. What this parameter estimate suggests is that high PCML attracted firms into the potato industry during early phases of potato processing, but these firms gradually left the industry as their profit margins were squeezed. Despite squeezes on industry profit margins, production of processed potatoes by the larger firms increased to accompany growing demands and the loss of production resulting from the demise of some firms. In the aggregate, these factors explain the apparent anomaly in the inverse relationship between PCML and CRP.

The parameter estimate for CT reveals a .07 percent increase in CRP for each unit increase in CT. This would suggest that transportation cost affects smaller firms more adversely than larger ones. Stated differently, larger potato processors absorb CT increases more readily than smaller processors. The one remaining parameter, that for cost of capital (CK), increases CRP by .15 percent for each unit increase in CK. This phenomenon was anticipated as larger firms usually have greater access to loanable funds on more favorable terms than smaller firms. It may be argued that larger potato processors also are likely to have greater accessibility to capital on more favorable terms relative to smaller processors.

Price Cost Margins (PCM)

Given the unexpected inverse relationship between concentration and profits established in the previous equation, it is therefore natural to find that increased CRP also leads to decreased PCM. The explanation for this relationship is analogous to that described in the previous equation. It may be noted here though that PCM, defined as the difference between wholesale and farm potato prices, have declined considerably because of large reductions in WPP. To some extent, changes in the marketing of potatoes may have made WPP less reflective of actual wholesale potato prices. Moreover, changes in the relative utilization of processed potato forms could have generated downward movements in WPP. As these alternative scenarios occurred, concentration in potato processing continually increased among the top four firms in all processed forms. The results of these occurrences explain the estimated inverse relationship.

It should be noted that the relationship between PCM and CRP is indeed weak. A one unit increase in CRP leads only to a .09 unit decrease in PCM. Similarly, a one percent increase in UCA causes a .02 decrease in PCM. A positive and stronger relationship exists between current and lagged profits. A one unit increase in PCML generates a .5 unit increase in PCM. Statistically, though, all of these relationships are significant, with PCM and UCA being the least significant. An increase in UCA generates a decrease in PCM because, as explained in the NPP equation, much of the increase in UCA is not demand or profit related. It arises from technological constraints imposed on smaller and perhaps less efficient potato processors.

Advertising Sales Ratio (AS)

Many industrial organization or market structure studies have confirmed a positive relationship between advertising and concentration (Sutton, 1974; Cable, 1973; Mann et al, 1967). Similar studies have also established a positive relationship between advertising and profitability (Comanor and Wilson, 1967; Williamson, 1963). Both of these relationships are estimated in the present equation. A positive relationship is established for the former but a negative one for the latter

An expected positive relationship between ASR and CRP stems from the hypothesis that firms in concentrated industries are more likely to use advertising than prices to influence sales (Hay and Morris, 1979). These authors argue that price changes by one firm can be matched by other firms more readily than changes in advertising expenditures because of the time required to plan effective advertising campaigns. For the potato industry, it is estimated that a one unit increase in CRP generates a very small .00005 unit increase in ASR. In advertising dollars, .00005 translates into approximately $1,500.

While the estimated sign of the parameters for CRP is as anticipated, that for PCMI defies our economic hypotheses. As explained in the concentration equation, PCM have declined considerably for the potato industry despite significant increases in other structural variables, including advertising. The estimated parameter suggests a .00045 unit decrease in ASR for each unit increase in PCML. This suggests that potato processors increase their advertising in response to factors other than profit rates.

Advertising expenditures may be in response to total profits or total sales.

The estimated parameters for the two potato utilization variables, UZF and UZP, conform to hypothesized relationships. As more potatoes are marketed as fresh, ASR declines, reflecting the lower advertising intensity of fresh potatoes. On the other hand, increased marketing of potatoes as processed leads to an increase in ASR. The estimated parameter shows that a one unit increase in UZP generates a .00003 unit increase in ASR. Statistically, the parameter estimates for UZP is significant at the .01 level while that for UZF is not significant even at the .10 level. In summary, potato processors can be predicted to increase their advertising in response to rising UZP with greater certainty than they can be predicted to reduce advertsing in response to rising UZF.

The two remaining variables of this equation, GR and GD, are both signed as hypothesized. As potato processors anticipate growth of the industry, advertising increases, but at a relatively insignificant rate. As the dispersion of raw potato production increases, precipitating perhaps more plants and firms within the industry, the sign of the parameter suggests that advertising declines. Statistically, however, this parameter estimate is nonsignificant. And while an economic interpretation of the intercept term is not always meaningful, suffice it to say here that the impact of all relevant omitted variables from this equation lead to a mean value in ASR of .0096.

Change in Capacity (CCA)

During the 1960-81 data period of this study, the processed potato industry has continually expanded its total capacity, but the annual percentage change in capacity has declined as a result of growing industry maturity. Also, growth of the industry has led to significant increases in the base used for calculating percentage changes. Hence, the larger base will generally lower the percentage during normal growing periods. That is, as total capacity rises, a constant numerical change in total capacity results in a diminishing percentage change in annual capacity. Despite these measurement limitations in the regressand variable, all but one of the estimated parameters have signs conforming with economic theory. Additionally, all parameters are statistically significant at the .05 level.

The Γ_{51} estimate reveals that a 1 unit increase in NPP causes a .0002 percent increase in CCA. This relatively small increase suggests that potato processing plants have increased considerably in size relative to number. Unexpectedly, the estimate for UCA reveals an inverse relationship between UCA and CCA. A one percent increase in UCA cause a .1712 decrease in CCA. This estimated result stems partly from measurement of the regressand variable and from increases in UCA as smaller firms and plants cease production. In other words, increases in UCA for the potato industry are not necessarily reflective of expanding demand conditions. Cessation of production by smaller firms with low utilization capacities engenders increases in UCA.

In conformity with the theoretical arguments, Π_{52} shows that a 1 unit increase in PCML causes a .008 percent increase in CCA. Potato processors, in other words, do respond to the profitability of the industry when expanding or contracting capacity. Rising capital cost, as expected, has a negative effect on capacity changes. A one unit increase in CK causes a .003 percent decline in CCA. These capital constraints are undoubtedly more prohibitive to smaller than larger firms. Interpreting the intercept, it is observed that the mean value of CCA resulting from omitted relevant economic variables is .089. Stated differently, when all the regressors have zero values, CCA has a value of .089.

Utilization of Capacity (UCA)

As explained in the discussions of previous equations, UCA for the potato industry has increased as a result of a growing demand for processed potatoes and a declining number of smaller plants with low capacity utilizations. This last mentioned condition is believed to have contributed to the unexpected negative signs for the parameter of UCA in three previously discussed equations. Though UCA is the regressand in the present equation, it may be noted that all its regressors have the anticipated signs, although one parameter estimate, Π_{62}, is statistically nonsignificant.

From the parameter estimates for equation 6.6 shown in Table 6.1, it can be seen that a 1 unit increase in NPP causes a .0003 percent decline in UCA. On the surface, the small magnitude of this parameter estimate would tend to suggest that new plants have not come on stream in excess of the growth in demand for processed potatoes. In light of the continual decline in NPP over the data period, this parameter estimate really says that potato processors have abandoned plants at a rate which has minimally increased UCA. Irrespective of which interpretation is applied, both being theoretically correct, the predicted occurrence can be stated with considerable confidence since the parameter estimate is significant even at the .01 level.

A 1 percent change in CCA generates a .008 percent decline in UCA. This inverse relationship was anticipated as potato processors, when expanding capacity, expand to accommodate not only current demands but anticipated growth in demands. This temporarily lowers UCA as production adjusts to prevailing demand. During the 1960-82 data period of this study, the processed potato industry has expanded considerably both total capacity and the utilization of this capacity. Just these facts alone suggest tremendous increases in consumption of processed potatoes.

The Γ_{6y} parameter reveals that a 10 pound increase in per capita consumption of processed potatoes generates a .007 percent increase in UCA. The likelihood of this occurrence cannot be stated with considerable confidence as the parameter is significant only at the .025 level. Changes in consumers' demand, however, do appear to be a barometer guiding potato processors' production decisions.

Unlike consumers' demand, the profitability of processed potatoes play a less significant role in processors' production decisions. Although an increase in PCML generates a positive response in UCA, statistically this response is nonsignificant. In other words, changes in PCML have not been a significant factor influencing the production of processed potatoes. The Π_{60} parameter of this equation may be interpreted as the mean value of UCA when all the regressors are zero. Its value of .589 may also be interpreted as the impact of the omitted relevant variables.

Significance of Structural Results

Many of the estimated structural relationships for the processed potato industry are direct opposites of those established for other industries. An important difference in these and other estimates is the nature of the data from which they are established. Most structural studies are single-equation models with data from a cross-section of industries. The present model is both dynamic and simultaneous with time-series data on a single industry. Thus, a single industry within a group of industries may differ significantly from the aggregate of the group. Moreover, the simultaneous-equation specification of the present model could have corrected for much of the model misspecification of the single-equation models (Gabel, 1979).

Assuming correct model specification and estimation, what general hypotheses describing the structure of the potato industry are embedded in the results of the previously discussed equations? Results of the first equation suggest that potato processors, in the early phases of development of the processed potato industry, were not guided by rational, economic factors. The industry over-expanded in terms of the number of plants (NPP) and, over time, reduced NPP despite growth in demand for processed potatoes. Also, revealed from the results of the first equation is the delayed response of potato processors in adjusting their plants to changing profit conditions. This suggests that potato processing plants are fairly capital-intensive with high fixed costs.

Another discernible hypothesis from the estimated structural equations is the relative unresponsiveness of potato processors to profit margins. It is conceivable, though, that the margins as defined really are a distortion of those received by processors. On the other hand, processors may be more inclined to view total sales and profits as more relevant factors than margins. To this end, the results support the hypothesis that advertising is used as a means to increase sales and profits.

The estimated results also show that the well-established positive relationships between concentration-profitability and advertising-profitability do not characterize the potato industry. Both concentration and advertising in the processed potato industry have increased considerably while profit-margins have fallen. These atypical relationships may be partly a function of the product nature. Most processed potatoes are available in generic and supermarket brands. These alternative products may serve to constrain price differentials even in a highly concentrated market with extensive advertising expenditures. Other industries, representing more typical relationships among these variables, may be less restrained by alternative product forms.

Despite the discussed atypical relationships, the processed potato industry has gravitated toward those factors generally characteristic of more progressive industries: concentration among the largest firms has increased; advertising expenditures together with product differentiation emphases have risen; and smaller firms have ceased production because of technological constraints. The divergent trend exemplified by profit margins probably is due to inherent characteristics of the industry rather than a departure from profit maximizing behavior by potato processors. Additionally, it may be that firms are pursuing increased market shares and growth as their primary objectives.

Market Equilibrium Results

Although results from the structural and market equilibrium sectors are discussed separately, there are obvious linkages between the sectors as both sets of variables are interspersed among equations of each sector. Among the market equilibrium equations, the two demand equations generate considerable interest. Fresh potato producers, in planning production, are interested in demand trends because many potatoes are not interchangeable in marketing. Thus, a movement away from fresh and toward processed potatoes could adversely affect fresh potato producers anticipating increased demand for fresh. Additionally, the demand for processed potatoes together with the determinants of this demand is of crucial importance to processors in planning production. The discussion which follows will therefore highlight these demand equations results.

Production of Fresh Potatoes (QRP)

Unlike the preceding structural equations which are estimated with principal components, this equation is estimated as a direct function of those variables suggested relevant from economic theory. No serious multicollinearity exists among the variables. All the estimated parameters are signed as anticipated and the two price parameters are highly significant. Risk (RS) and technological change (TR), as measured by the trend variable, are statistically nonsignificant.

The estimated results shown in Table 6.2 illustrate that lagged prices of both potatoes and an alternative product (sugar beets) are significant determinants of current production. An increase in potato prices of $1 per hundred weight generates a twenty one pound per capita increase in potato production in the next season. These parameters translate into a price elasticity of supply of .31. Specifically, a one percent increase in the lagged price engenders a .3 percent increase in supply. By contrast, a one percent increase in the price of sugar beets causes a .1 percent decline in potato production; the derived elasticity is -.0987. These inelastic supply responses suggest that potatoes are produced on specialized farms with sugar beets being an imperfect crop substitute. Beilock (1981) and Estes (1979) reached similar conclusions.

The statistical nonsignificance of the parameters for risk and technological change indicates that, while potato producers may be cognizant of these factors, their production levels are not responsive to them. If potato farms are highly specialized as suggested by the elasticity estimates, then producers may be less responsive to price risk because of limited alternatives. Additionally, while available technology may expand yields per acre, demand constraints may serve to restrain its adoption. Finally, the Π_{70} parameter of this equation has only a limited economic interpretation.

Utilization of Fresh Potatoes (UZF)

Changing consumption of fresh potatoes is a phenomenon that has been the subject of many research studies. For almost a century now, per capita consumption of fresh

Table 6.2--Parameters and Statistics for Market Equilibrium Equations

QRP Equation 6.7

VARIABLE	NSTAD-B	STAD-B	STAD-ERR	T-RATIO
INTRC (Π_{70})	-634.24	-	491.17	-1.29
RS ($\Pi_{7,10}$)	-.13	-	.17	-.79
TR (Π_{79})	.30	-	.24	1.23
PS (Π_{76})	-20.70	-	7.42	-2.78
FPRL (Π_{77})	21.22	-	2.74	7.73
UZF		Equation 6.8		
INTRC (Π_{80})	62.76	-	.59	105.48
RPF ($\Gamma_{8,10}$)	-.35	-.32	.32	-1.02
RPP ($\Gamma_{8,11}$)	1.92	3.01	.51	5.87
RPT ($\Gamma_{8,14}$)	-.55	-.34	.33	-1.04
GC ($\Pi_{8,11}$)	-29.57	-1.22	.13	-9.26
TF ($\Pi_{8,12}$)	-.0002	-1.33	.11	-11.17
PF ($\Pi_{8,13}$)	-17.4022	-1.58	.07	-22.37
PN ($\Pi_{8,14}$)	-.111	-1.63	.06	-24.63
IN ($\Pi_{8,15}$)	-.0052	-2.09	.15	-13.58
WN ($\Pi_{8,16}$)	-41.43	-1.38	.10	-12.98
UZP		Equation 6.9		
INTRC (Π_{90})	59.94	-	1.24	48.31
ASR (Γ_{94})	1308.08	3.00	.39	7.66
RPF ($\Gamma_{9,10}$)	-.20	-.18	.70	-.26
RPP ($\Gamma_{9,11}$)	-2.35	-3.68	.58	-6.26
RPT ($\Gamma_{9,14}$)	-.81	-.51	.50	-1.02
GC ($\Pi_{9,11}$)	18.58	.76	.26	2.87
TF ($\Pi_{9,12}$)	.0001	.94	.23	4.02
PF ($\Gamma_{9,13}$)	13.97	1.27	.16	7.50
PN ($\Pi_{9,14}$)	.09	1.36	.15	8.95
IN ($\Pi_{9,15}$)	.0056	2.22	.16	13.28
WN ($\Pi_{9,16}$)	26.97	.90	.24	3.68
ASRL ($\Pi_{9,20}$)	1159.69	2.79	.34	8.01
RPP		Equation 6.11		
INTR ($\Pi_{11,0}$)	-320.25	-	171.95	-1.86
WPP ($\Gamma_{11,12}$)	1.72	-	.41	4.18
TR ($\Pi_{11,9}$)	.16	-	.08	1.88
FPR		Equation 6.13		
INTRC ($\Pi_{13,0}$)	7.019	-	1.256	5.588
QRP ($\Gamma_{13,7}$)	-.018	-	.008	-2.203
QRPL ($\Pi_{13,19}$)	-.013	-	.005	-2.454

Table 6.2--Continued

SPR Equation 6.15

VARIABLE	NSTAD-B	STAD-B	STAD-ERR	T-RATIO
INTRC ($\Pi_{15,0}$)	5.29	-	.37	14.09
MC ($\Pi_{15,8}$)	.35	-	.22	1.57

Note that each dependent variable and equation number correspond to those in Tables 4.1 and 6.3.

potatoes has been declining. The first few decades of this decline were long before the present revolution in processed potato products. Researchers have offered explanations of this decline which range from the growing urbanization of the U.S. population to a increasing demand for convenience foods as represented, for example, by processed potato products (Scott and Mumford, 1949; Estes, 1979). The current study, while addressing many of these previously addressed factors, integrates structural and market equilibrium changes in the potato industry and discovers findings which contrast with those of previous studies. These contrasts are quite evident in the results of this demand equation.

When all the changes occurring in the U.S. potato industry are analyzed in a simultaneous and dynamic framework, as is done here, results show that those exogenous factors influencing the demand for fresh potatoes all have negative impacts. In contrast, these same factors have positive impacts on the demand for processed potatoes. These findings are significant because previous studies have found a positive relationship between demand for fresh potatoes and income. Additionally, other studies have found the retail price of fresh potatoes (RPF) to have a significant and adverse impact on fresh demand (Beilock, 1981; Estes, 1979). While a negative coefficient is estimated in the present equation, it is statistically nonsignificant.

As shown in Tables 6.2 and 6.3, an increase of one unit in RPP causes a 1.9 unit increase in UZF. This yields a demand elasticity of .34. Specifically, a one percent increase in RPP generates a .34 percent increase in UZF. This response in demand, relative to $\Gamma_{8,10}$, suggests that processed potatoes are far superior to fresh potatoes in consumers' diets. Additionally, it seems prudent to conclude that UZF is somewhat unresponsive to RPF because fresh potatoes are a small proportion of consumers' food expenditures. The derived elasticity of -.0451, although derived from an nonsignificant parameter, reveals that a one percent increase in RPF causes a .04 percent decrease in UZF.

The $\Gamma_{8,14}$ estimate for RPT is not only statistically nonsignificant but also negatively signed. What appears to be suggested by this parameter estimate is that either the duration of this tax is yet too short to have a significant impact on fresh potato consumption or other factors have tended to negate its impact. An increasing number of women in the labor force coupled with rising incomes, for example, could have offset the expected positive effects from the tax. Additionally, advertising expenditures on potatoes relative to expenditures from the tax are so dominant that the effects of this tax are likely captured in these expenditures. Although advertising expenditures are not represented in this equation directly, their impacts are transmitted through the UZP equation as the two equations are mirror images of each other.

The $\Pi_{8,11}$ parameter estimate for GC was expected to be positive because of observed habit persistence of consumers. The observed estimate is negative and significant even at the .01 level. What may be reflected in this parameter estimate is the fact that consumers, although somewhat habit persistent, are capable of altering their habits as a product becomes less and less preferred. Indeed this attribute of consumers is also confirmed by the parameter estimates for TF ($\Pi_{8,12}$). As away-from-home food consumption increases, consumers are expressing a declining preference for fresh potatoes as a proportion of total consumption.

While the parameter estimate for fast food (FF), $\Pi_{8,13}$, has the anticipated sign and is highly significant, this is due in part to the trend of UZF being negatively impacted by all exogenous variables. As estimated here, a one percent increase in FF causes a .17 unit decrease in UZF. From an elasticity viewpoint, a one percent increase in FF causes a .07 percent decline in UZF (Table C.5). More significant impacts result from changes in population and income. Translating the $\Pi_{8,14}$ and $\Pi_{8,15}$ estimates into elasticities, it is revealed that a one percent increase in PN causes a .36 decline in UZF whereas a one percent increase in IN generates a .24 percent decline in UZF. It should be noted that both of these variables were hypothesized to have positive impacts on UZF. However, revealed estimates suggest that population and income have accelerated demand for processed potatoes at the expense of fresh potatoes.

A glance at Table 6.2 shows a negative and significant parameter estimate for WN. Embedded in this parameter estimate is an elasticity of -.24. That is, a one percent increase in WN leads to a .24 percent decline in UZF. This elasticity estimate is quite inelastic when compared to those obtained in recent studies of the potato industry. The elasticity derived here though may not be comparable with those of previous studies as these studies have allowed WN to encompass several variables which are estimated separately in this study. In Estes' (1979) study, for example, his elasticity estimate for WN is really comparable in this study to the sum of the elasticities for WN, GC, TF, FF and PN. The sum of these elasticities in the present study is 1.087 whereas Estes' (1979) estimate is 1.056. These two estimates are quite similar, but there is considerable difference in the income elasticities of .11 reported by Estes (1979) and -.24 derived here.

To recapitulate, the demand for fresh potatoes at present is impacted positively only by increases in the price of processed potatoes. Increases in the price of fresh potatoes and rising tax expenditures tend to have no measurable impact on demand. Increases in all the exogenous variables have adverse and significant impacts on demand. These effects are most pronounced for population and retail produce sales.

Utilization of Processed Potatoes (UZP)

The current structure and growth of the potato industry are probably linked more to the demand for processed potatoes than any other factor. Factors that have precipitated change in this demand are estimated in this equation. From Table 6.2, it can be seen that all but two estimated parameters not only have the anticipated signs but are statistically significant. Those parameters with signs opposite of those hypothesized also are statistically nonsignificant.

A significant factor influencing the demand for processed potatoes is advertising, both current and lagged. The Γ_{94} parameter reveals that a one percent increase in ASR generates a 13 unit increase in UZP. In addition to this immediate effect of advertising, lagged advertising, expressed by $\Pi_{9,20}$, generates a corresponding 11 unit increase in UZP for each one percent increase in ASRL. Expressed as an elasticity, a one percent increase in ASRL causes a .18 percent increase in UZP. The corresponding elasticity for ASR is .21. The combined effects of advertising are therefore significant in enhancing the demand for processed potatoes.

The $\Gamma_{9,10}$ parameter of -.20 has a sign opposite of that anticipated. Its statistical nonsignificance, however, suggests that the demand for processed potatoes is not influenced by the retail price of fresh potatoes. Changes in the retail price of processed potatoes, however, do have an adverse and significant influence on UZP. The derived elasticity from $\Gamma_{9,11}$ shows that a one percent increase in RPP leads to a .44 percent decline in UZP. Reflected in these price parameters is the fact that consumers do not switch forms of potato consumption as prices change. Rather, price changes in potatoes precipitate a switch from potatoes to other products.

As in the demand for fresh potatoes equation, the parameter estimate for RPT, $\Gamma_{9,14}$, has a sign opposite of that hypothesized; it is also statistically nonsignificant. Given the relatively insignificant ratio of tax expenditures to advertising expenditures, it is probably safe to surmise that the effects of these tax expenditures are captured in the advertising parameters. The recent enactment of the tax, 1971, may also be a factor influencing its estimated parameters.

The $\Pi_{9,11}$ parameter for GC was hypothesized to be positive provided there existed complementarity in demand for fresh and processed potatoes. Estimated price parameters seem to confirm complementarity. Therefore the estimated parameter may be said to conform to apriori assumptions. As shown in Table 6.2, and as may have been expected, $\Pi_{9,11}$ is less significant than the parameter estimates for the remaining exogenous variables. Deriving an elasticity estimate from the 18.59 parameter estimate, it is revealed that a one percent increase in GC causes a .21 percent increase in UZP.

Changes in away-from-home food consumption were hypothesized to have positive and significant impacts on UZP. As shown in Table 6.2, both $\Pi_{9,12}$ and $\Pi_{9,13}$ are positive and indeed significant statistically. Their impacts, from an elasticity concept, are smaller than that of the other exogenous variables. One percent changes in TF and FF cause .07 and .06 percent changes in UZP respectively. By contrast, a one percent change in PN generates a .32 percent change in UZP. It should be emphasized, though, that FF has been changing more than ten times the rate of PN; and TF has been changing more than four times the rate of PN. On balance, then, away-from-home food consumption is significant in influencing the demand for processed potatoes.

As alluded to above, the $\Pi_{9,14}$ parameter estimate for PN suggests that this variable has a tremendous impact on UZP. What is really reflected here is the fact that sizeable increases in the U.S. population would enhance UZP considerably. At present, the relatively constant growth rate of less than one percent per year results in a meager impact on UZP in comparison to, say, TF and FF. While changes in away-from-home food sales have greatly outdistanced that of population, changes in income and women-in-the labor force are comparable. Deriving elasticities from $\Pi_{9,15}$ and $\Pi_{9,16}$, it is revealed that one percent changes in IN and WN generate corresponding changes in UZP of .27 and .17 respectively. With WN changing at only a slightly higher rate than PN, then it seems safe to surmise that PN has a greater impact than WN on UZP. Since IN has changed by 1.5 times the rate of PN, comparison of elasticities would suggest that IN has a greater impact on UZP.

In summary, RPP seems to greatly impact UZP, but RPF has essentially no effect. Both current and lagged advertising greatly influence UZP. Away-from-home food consumption, reflected in TF and FF, appear to be major stimulants of demand for processed potatoes. The remaining exogenous variables also have notable impacts on UZP, that of IN being perhaps most notable. Lastly, providing an economic interpretation for Π_{90}, it may be argued that all the relevant variables omitted from this equation would provide a mean consumption level of 59.9 units of processed potatoes.

Retail Price of Fresh Potatoes (RPF)

In Chapter IV it was hypothesized that RPF would differ from the farm price (FPR) by the cost of marketing potatoes. Because data on the marketing cost of potatoes were not accessible, an index of the marketing cost of fresh vegetables (MC) was used as a proxy. Using the difference of the two prices (RPF - FPR) or SPR as the dependent variable, this equation is estimated as a function of MC. The results are shown in Table 6.2, equation 6.15.

The estimated $\Pi_{15,8}$ parameter has the anticipated sign but it is statistically nonsignificant. This suggests that

MC is either a poor proxy for the marketing cost of potatoes or many other variables, separately or together with FPR, account for the variation in RPF. The R^2 statistics of .11 (2SLS) means that only eleven percent of the variation in the dependent variable is explained by MC (Table C.4). This statistic together with the nonsignificance of the parameter estimate is difficult to explain, particularly since potatoes are the largest proportion of fresh vegetables. The $\Pi_{15,0}$ parameter suggests that variables omitted from this equation results in a mean price of 5.29 units.

Retail Price of Processed Potatoes (RPP)

Unlike the preceding equation which yielded poor results, parameter estimates in the present equations have the anticipated signs and are statistically significant. As seen in Table 6.2, equation 6.11, a one unit change in WPP results in a 1.7 unit change in RPP. This suggests that all price changes at the wholesale level, plus an element of profit, are passed on to consumers at the retail level. Additionally, the $\Pi_{11,9}$ parameter for TR reveals a widening of price changes at the wholesale and retail levels. In other words, each unit price change at the wholesale level is reflected over time as a larger price change at the retail level. The magnitude and sign of $\Pi_{11,0}$ do not have a clear economic interpretation. Granting an interpretation analogous to those in preceding equations, it is noted that those relevant but omitted variables result in an average price of processed potatoes of -320.25 per hundredweight of potatoes.

Farm Price of Fresh Potatoes (FPR)

The farm price of potatoes was hypothesized in Chapter IV to be a function of production in the current and previous periods. From Table 6.2 it can be seen that both QRP and QRPL do have the anticipated effects on FPR and these effects are statistically significant at the .05 level. Changes in QRP impact FPR to a slightly greater extent than changes in QRPL. Together, however, these two variables explain only 22 percent of the total variation in FPR (2SLS). Thus, the R^2 statistic indicates that other factors account for much of the variation in FPR. On the other hand, and as explained in Chapter IV, changes in potato production generally cause greater changes in prices because of the low elasticity of demand for potatoes at the farm level. Lastly, the $\Pi_{13,0}$ parameter reveals that the omitted variables from this equation result in an average FPR of 7.019.

Significance of Market Equilibrium Results

Several important factors are revealed in the empirical results of the market equilibrium equations. Noticeable results from the production equation are the limited responses of production to risk and technology. These facts result partially because potato production occurs on farms which are large and specialized. Moreover, size and specialization together with limited cropping alternatives tend to constrain the response of production to price risk. Production, however, does respond to potato prices of the previous period.

From the two demand equations, neither fresh nor processed potato consumption is impacted by price changes of fresh potatoes at the retail level. Price changes of processed potatoes at the retail level, however, do positively impact fresh potato consumption and negatively impact processed potato consumption. Suggested here is the fact that consumers have a stronger preference for processed than for fresh potatoes; switching from processed to fresh potatoes occurs only as processed prices rise considerable. Significant price increases of fresh potatoes at the retail level do not precipitate a switch to processed potatoes. This may be due to a favorable nutrients/cost ratio of fresh potatoes as compared to other commodities.

Also significant among the results of the two demand equations are the negative and consistent impacts of exogenous variables on demand for fresh potatoes; yet, these same variables have positive and strong impacts on demand for processed potatoes. Changes exogenous to the potato industry obviously influence consumption of processed potatoes at the expense of fresh. Among these exogenous variables, away-from-home food consumption is the leading determinant of growth in processed potato consumption.

From the results of the retail price equations, retail prices of fresh potatoes are poorly explained by farm potato prices and marketing cost. Wholesale prices of processed potatoes and the trend variable explain most of the variation in prices of processed potatoes at the retail level. Poor results for retail prices of fresh potatoes may be due to the inability to capture actual demand elasticities within the equation. Potato prices at the farm level also are poorly explained by potato production in the current and previous periods.

The empirical results show the effectiveness of advertising in influencing potato consumption. Indeed advertising expenditures are so large relative to expenditures from the research and promotional tax that the effects of the generic promotion is confounded within the larger promotional effort. Not only is current advertising effective, but there is an almost equal carryover effect into the next period. In addition to the imbalance of advertising and tax expenditures, the relative effectiveness of advertising may be due to its product differentiation emphases.

In summary, production of potatoes on large, specialized farms appears to make production somewhat unresponsive to the hypothesized response variables, especially technology and risk. Consumption of processed potatoes is unrelated to changes in fresh potatoes prices at the retail level. Exogenous factors, such as growth of away-from-home food consumption and women in the labor force, have significant impacts on consumption of processed potatoes. Retail prices of processed potatoes are explained considerably by changes in the wholesale price of processed potatoes. Retail and farm prices of fresh potatoes reveal weak results in the present model.

Summary of Structural and Market Equilibrium Results

Though the discussion heretofore has delineated results from the structural and market equilibrium equations or sectors, it should be emphasized that effects from each sector reverberate throughout the system. For example, the structural variable PCM impacts the market equilibrium variable WPP; WPP impacts RPP, another market equilibrium variable; RPP impacts both demand variables, UZF and UZP; both demand variables impact ASR, a structural variable; and so forth. Thus, the results for each sector are interdependent. Included here, therefore, is an integrated discussion of the system.

The estimated results of the present model show the structure of the U.S. potato industry to change primarily in response to forces external to the industry. These forces, captured partly in the growing demand for processed potatoes, engendered structural changes that appear to be anomalies. More subtle examinations, however, reveal that the potato industry has been guided by rational economic decisions. In early phases of development of processed potato products, consumer undoubtedly were willing to pay relatively high prices for potato products as these products were small proportions of their total expenditures. As taste for these products grew along with the specificity of product characteristics, consumers' demand expanded in response to price reductions. These declining prices were accompanied by structural changes that theoretically would accompany rising prices. Thus, ostensible anomalies prevailed.

Because structural changes in the U.S. potato industry are not independent of market equilibrium changes, the ostensible anomalies are explainable. As consumers were expressing a growing preference for processed over fresh potatoes, processors responded to this demand and enhanced it. Because specific product characteristics were inherent in this demand, processors unable to meet this specificity simply left the industry during these periods of considerable growth and expansion. The industry therefore became more concentrated, increased its use of advertising expenditures, and expanded its total sales.

As the above changes occurred, consumption of fresh potatoes declined, prompting the potato industry to initiate an income-generating tax to promote consumption of fresh potatoes. Advertising expenditures for processed potatoes, in comparison to tax expenditures, were large enough to absorb the tax effectiveness. Meanwhile, potato production gravitated to those areas engaged heavily in potato processing. These shifts in potato production resulted in lost marketing alternatives for many producers, especially smaller ones.

Table 6.3--Estimated Parameters for System of Equations in U.S. Potato Subsector

Eq.	Endogenous Variables															
	NPP	CRP	PCM	ASR	CCA	UCA	QRP	UZF	UZP	RPF	RPP	WPP	FPR	RPT	SPR	UZO	C
4.1	-1		.3804			-144.530											352.70
4.2	-.0077	-1		272.668													64.607
4.3		-.907	-1			-2.1927											5.8404
4.4		.000047		-1				-.000013	.000033								.0096
4.5	.0002				-1	-.1712											.0892
4.6	-.00026				-.8460	-1			.00065								.5894
4.7							-1										-634.24
4.8								-1		-.3547	1.9228			-.5514			62.767
4.9				1308.08					-1	-.2022	-2.3507			-.8176			59.94
4.10										-1			1		1		-
4.11											-1	1.7276					-320.25
4.12			1									-1	1				
4.13							-.0186						-1				7.0196
4.14								.01	.01					-1			
4.15															-1		5.2918
4.16							-1	1	1							1	

Table 6.3--Continued

Eq.	MS	PCML	CT	GD	CK	PS	FPRL	MC	TR	RS	GC	TF	FF	PN	IN	WN	GR	UZPL	QRPL	ASRL
	Exogenous Variables																			
4.1	-1.3023	1.9917	-3.6574	364.42													-.6869	-.5524		
4.2	.05911	-.3938	.06945		.1468															269.984
4.3		.4758																		
4.4		-.0005		-.0041																
4.5		.0083			-.0038															
4.6		.0010																		
4.7						-20.71	21.22		.3073	-.1373									1	
4.8											-29.577	-.00025	-17.402	-.1113	-.005	-41.433				
4.9											18.585	.00018	13.97	.0925	.0056	26.9774				1159.69
4.10																				
4.11									.1611											
4.12																				
4.13																			-.0137	
4.14																				
4.15								.3551												
4.16																				

CHAPTER VII
USING THE MODEL

Introduction

This chapter has a twofold purpose: (1) to report the performance of the potato industry as determined from the reduced and final forms of the model; and (2) to report forecasted changes in the potato industry emanating from three alternative growth scenarios of the exogenous variables. Performance measures obtainable from simulating the reduced and final forms are (1) root-mean-square (RMS) error; (2) root-mean-square (RMS) percent error; and (3) sensitivity to turning points. Dynamic multipliers, derivable from the final form, also will be used to evaluate the long term impacts of exogenous variables. Forecasts of endogenous variables in the model will be calculated assuming changes in the exogenous variables at (1) their mean rates for the 1976-81 period (moderate growth), (2) twenty five percent above mean rates (rapid growth), and (3) twenty five percent below mean rates (slow growth).

Performance Of The Model

Reduced and Final Forms

Many interrelationships among the system of equations in Table 4.1 have been discussed in Chapter VI in relation to the Γ and Π parameters. The full system was shown in

Table 6.3. Further insights into these interrelationships are discernible from the reduced and final forms of the model. By using the reduced forms to estimate predicted values and then to plot these against actual values, a measure of performance is ascertained and depicted.

Let the system of equations shown in Tables 4.1 and 6.3 be written in general notations as

$$(7.1) \quad Y_t\Gamma + X_t\Pi = E_t$$

It can be easily shown that the reduced form may then be written as

$$(7.2) \quad Y_t = X_tB + U_t$$

where $\beta = -\Pi\Gamma^{-1}$ and $U_t = E_t\Gamma^{-1}$. Since in this model there are lagged endogenous variables, a more meaningful and revealing way of writing (7.1) is

$$(7.3) \quad Y_t\Gamma + Y_{t-1}\Pi_1 + W\Pi_2 = E_t$$

where Y_{t-1} are lagged endogenous variables previously embedded in X_t and W_t is the subset of X_t that are exogenous variables throughout the model. Equation 7.3 in its reduced form becomes

$$(7.4) \quad Y_t = Y_{t-1}\beta_1 + W_t\beta_2 + U_t$$

where $\beta_1 = -\Pi_1\Gamma^{-1}$, $\beta_2 = -\Pi_2\Gamma^{-1}$, and U_t is as defined in (7.2). By iteration, the final form of (7.4) can be derived as shown in equation 7.5.

$$(7.5)\quad Y_t = Y_0\,\beta_1^t + \sum_{j=0}^{t-1} W_{t-j}\,\beta_2\beta_1^j + \sum_{j=0}^{t-1} U_{t-1}\,\beta_1^j$$

where β^j implies the matrix product up to the jth time. This equation shows that each endogenous variable is a function of the base value of the endogenous variables, the current and lagged values of the exogenous variables, and current and lagged values of the error terms. As expressed here, this final form equation is most useful for determining dynamic multipliers. That is, multipliers are derived which characterize the impacts on endogenous variables resulting from previous and current changes in exogenous variables. Alternatively, they characterize subsequent changes in endogenous variables resulting from current changes in exogenous variables. For example, how is the consumption of processed potatoes (UZP) in 1984 impacted by an increase of fast-food sales (FF) in 1981? Such an answer is embedded in the coefficients of ΣW_{t-j} in equation 7.5 and will be discussed subsequently.

Although empirical results from the reduced forms of both 7.2 and 7.4 are derived and discussed throughout this chapter, it should be emphasized that plots of predicted values depicted in Figure 7.1 through 7.16 are based on the reduced form of equation 7.2. This reduced form fully captures the data from which the structural parameters in Table 4.1 are estimated. Having determined these predicted values, the reduced form in equation 7.4 is used, in turn, to derive dynamic multipliers. These forms differ only by their use of the actual lagged endogenous variables rather than the estimated endogenous variables. In the former, lagged endogenous variables consist of their actual values while the predicted values are in the latter. Despite these differences, multipliers from the latter are applicable to the former reduced form.

Depicted in Figures 7.1 through 7.16 are actual, predicted and forecasted values for the endogenous variables. The actual and predicted values are for the 1960-81 data period. Forecasts are provided for 1982-1990. This next section, however, will focus solely on the performance of the model during the 1960-81 data period. Forecasts are discussed in a subsequent section.

Reduced and Final Forms for Structural Equations

Analyses of performance for econometric models have shown that smooth, slow-moving variables are more accurately predicted than those exhibiting high variance and large fluctuations from period to period (Fromm and Klein, 1976). While these analyses have applied primarily to macro-econometric models, these findings to a large extent characterize the present model.

As shown in Figure 7.1, actual potato processing plants (NPP) have exhibited a smooth pattern of change except for the earlier years. Predicted values closely parallel actual levels for most of the data period, but they fail to trace erratic changes for 1960-65. Much of this decline in NPP since 1965 is attributable to changes in minimum efficient

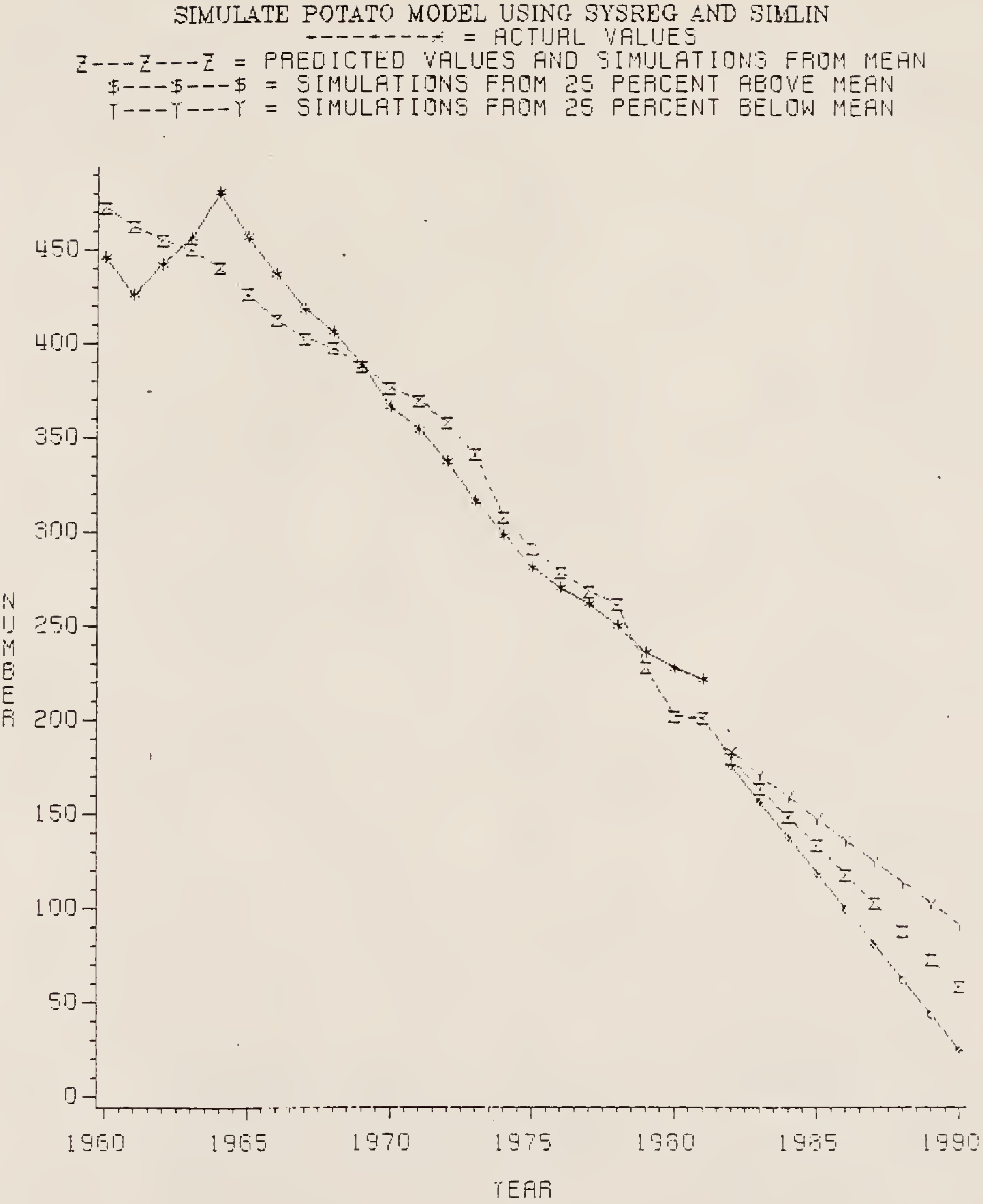


Figure 7.1. Actual, Predicted and Simulated Values for Potato Processing Plants

plant size (MS) and cost of capital (CK) as shown with equation 6.1 of Table 6.3. Dynamic multipliers for these variables together with their rates of change over the data period show considerable effects on NPP. Unit changes in CT and MS lead to declines of 3.9 and 1.4 units respectively in NPP. These same period effects are characterized as impact multipliers. Multipliers for all variables are shown in Table C.6.

Dynamic or interim multipliers for these variables show that there also are carryover effects. For example, a one unit increase in MS (1,000 pounds per hour processing capacity) in period t-1 leads to a decrease in NPP in period t of .05 units. The corresponding multiplier for CT leads to a decline of .09 units in NPP. Summing these interim multipliers from the base year forward, it is revealed that the long run impact of unit increases in CT and MS are losses of 4.2 and 1.6 units respectively in NPP.

Figure 7.1 shows clearly that this reduced form traces the trend in NPP. Note that predicted NPP drops sharply from 1978-81. This undoubtedly is due to unprecedented increases of more than 100 percent in the interest rate (CK). Because potato processors probably have access to some internal finances, the last few predicted values are likely distorted by the unexpected surge in CK. Despite these wide deviations for the last few years, overall performance for this reduced form seems highly acceptable as measured by the low RMS percent error of 5.6. The RMS error of 19.7 is also quite low relative to the 352.7 mean value of NPP. These statistics are shown in Table C.7.

As seen in Figure 7.2, the reduced form equation performs well for concentrating (CRP). The upward trend not only is duplicated, but most turning points along this trend also are captured. Both the RMS error and RMS percent errors are exceptionally low, respectively 1.3 and 2.1. Mean concentration for the top four potato processors during the data period amounted to market shares of 64.6 percent. Thus, all three performance measures are exceptional for this reduced form.

Changes in transportation cost (CT) had a significant impact on CRP as seen in Table 6.1. The impact multiplier shows that each $1 increase in CT ($ per hundred gallons of diesel fuel) causes CRP to increase .1 percent. The corresponding long term multiplier is .13 percent. With only a .03 percent difference between the impact and long-term multiplier, it readily follows that there is little carryover effect from changes in CT. This impact of CT on CRP conforms with findings by Beilock (1981) that rising energy cost leads to greater regional concentration of production. An extension of this result suggests that greater regional concentration leads to or is tantamount to greater firm concentration.

Another reduced form equation exhibiting good performance is that for price cost margins (PCM). A glance at Figure 7.3 reveals that PCM is predicted well despite

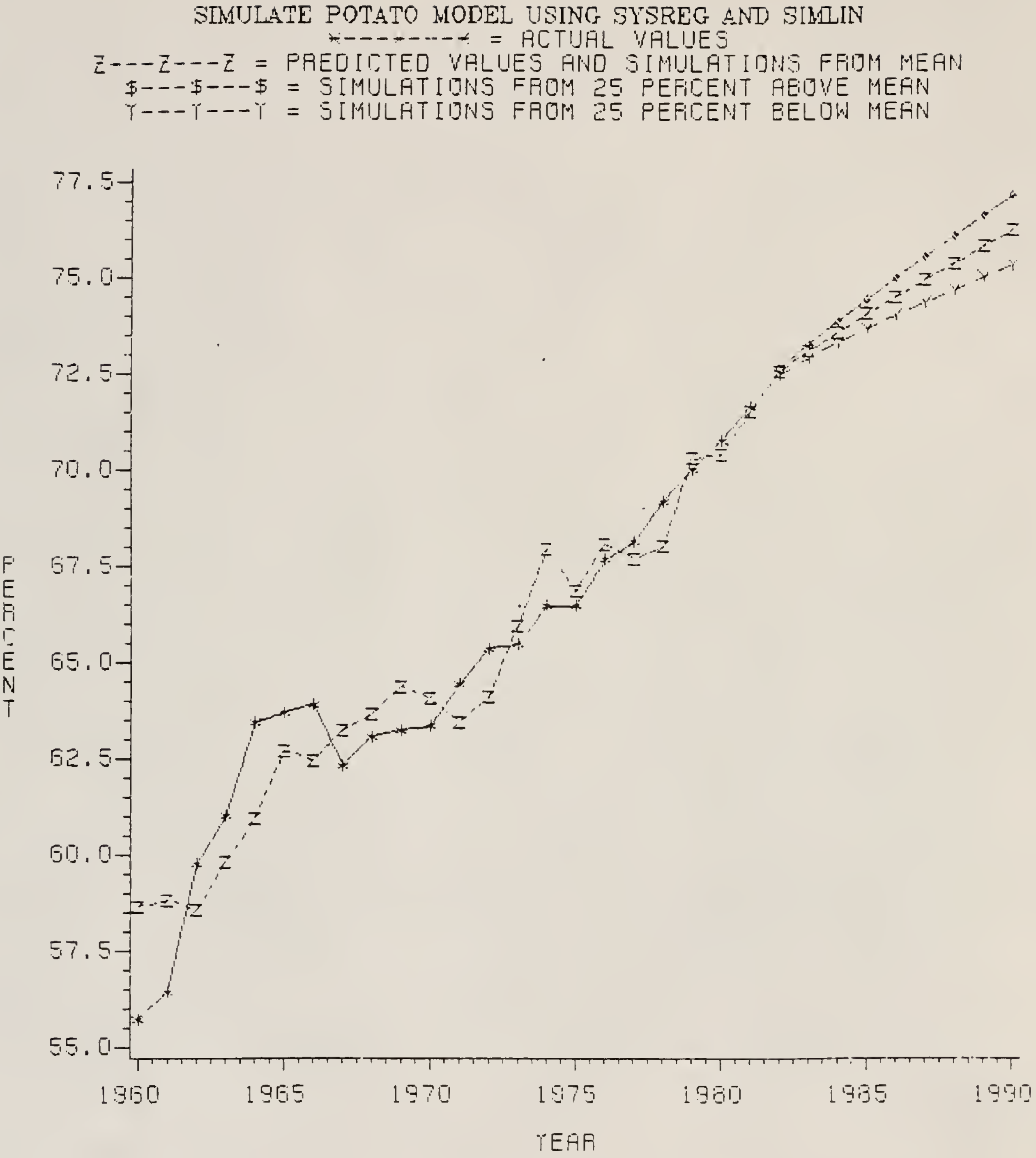


Figure 7.2. Actual, Predicted and Simulated Values for Concentration

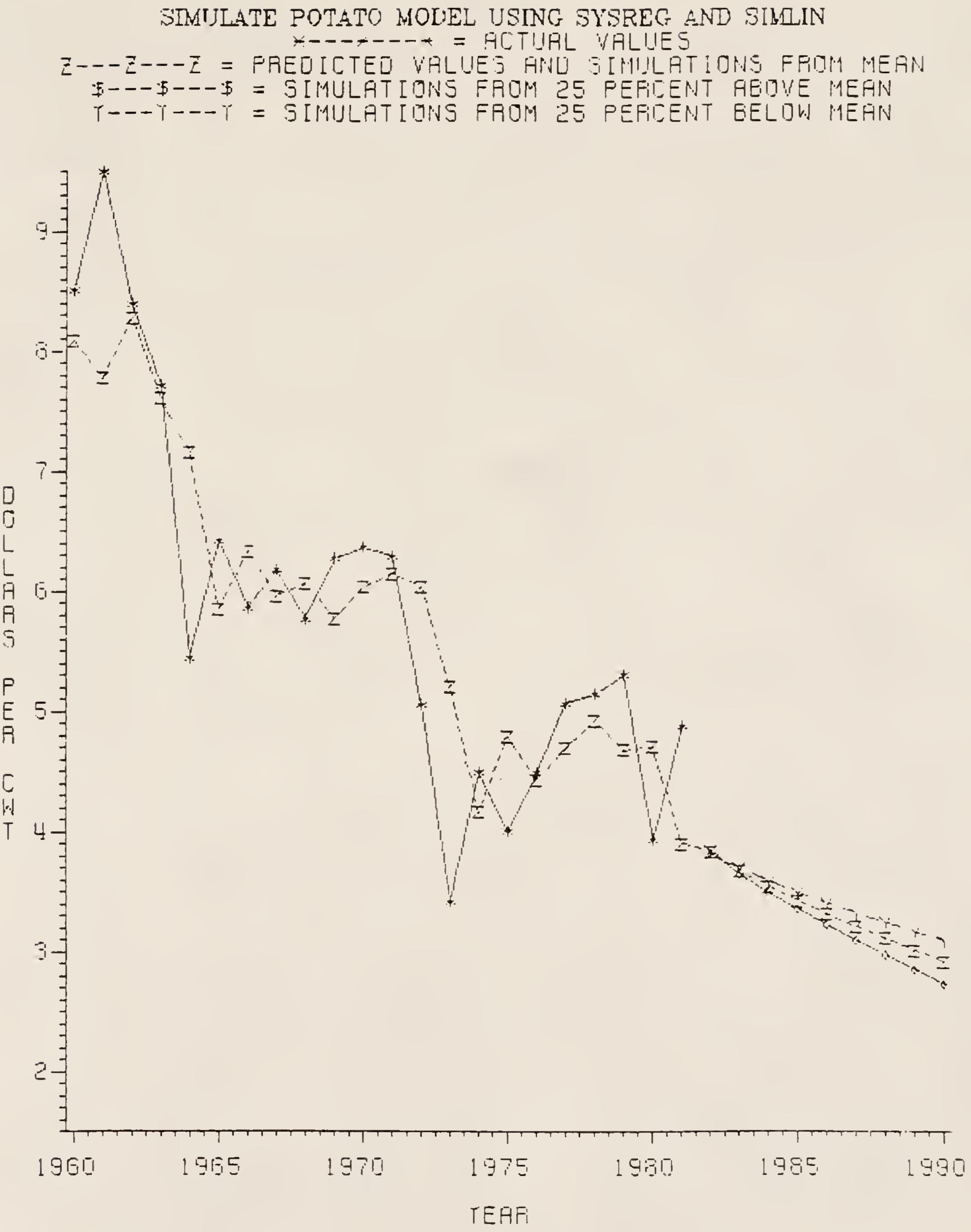


Figure 7.3. Actual, Predicted and Simulated Values for Price Cost Margins

large fluctuations in actual margins. Many turning points are predicted and there is a reasonable correlation of predicted and actual values, although at times predicted values appear to be off one period.

The RMS percent error of 16.8 for PCM, though higher than for the previous two variables, seems reasonable by statistical standards. A RMS error of .8 is observed, but it is only meaningful relative to the 5.84 mean value for PCM. As another measure of performance, predicted values were derived using 1965 instead 1960 as the initial simulation period. This change, though results are not shown, did not lead to a deterioration in performance as measured by RMS errors and sensitivity to turning points.

It is discernible from the multipliers that several exogenous variables with positive and significant impacts on the demand for processed potatoes also have significant but negative impacts on margins. As an example, the long-term impact of a 1 percent increase of WN is a .014 percent increase in CRP, but a .004 unit decrease in PCM. In sum, rising concentration has been accompanied by lower instead of higher margins.

Though the reduced form for ASR, depicted in Figure 7.4, shows low sensitivity to turning points, its performance as measured by the low RMS percent error of 16.6 seems quite acceptable. A corresponding RMS error of .001 is observed but this must be evaluated in light of the .01 mean value for ASR. Some of the fluctuation in ASR is probably weather

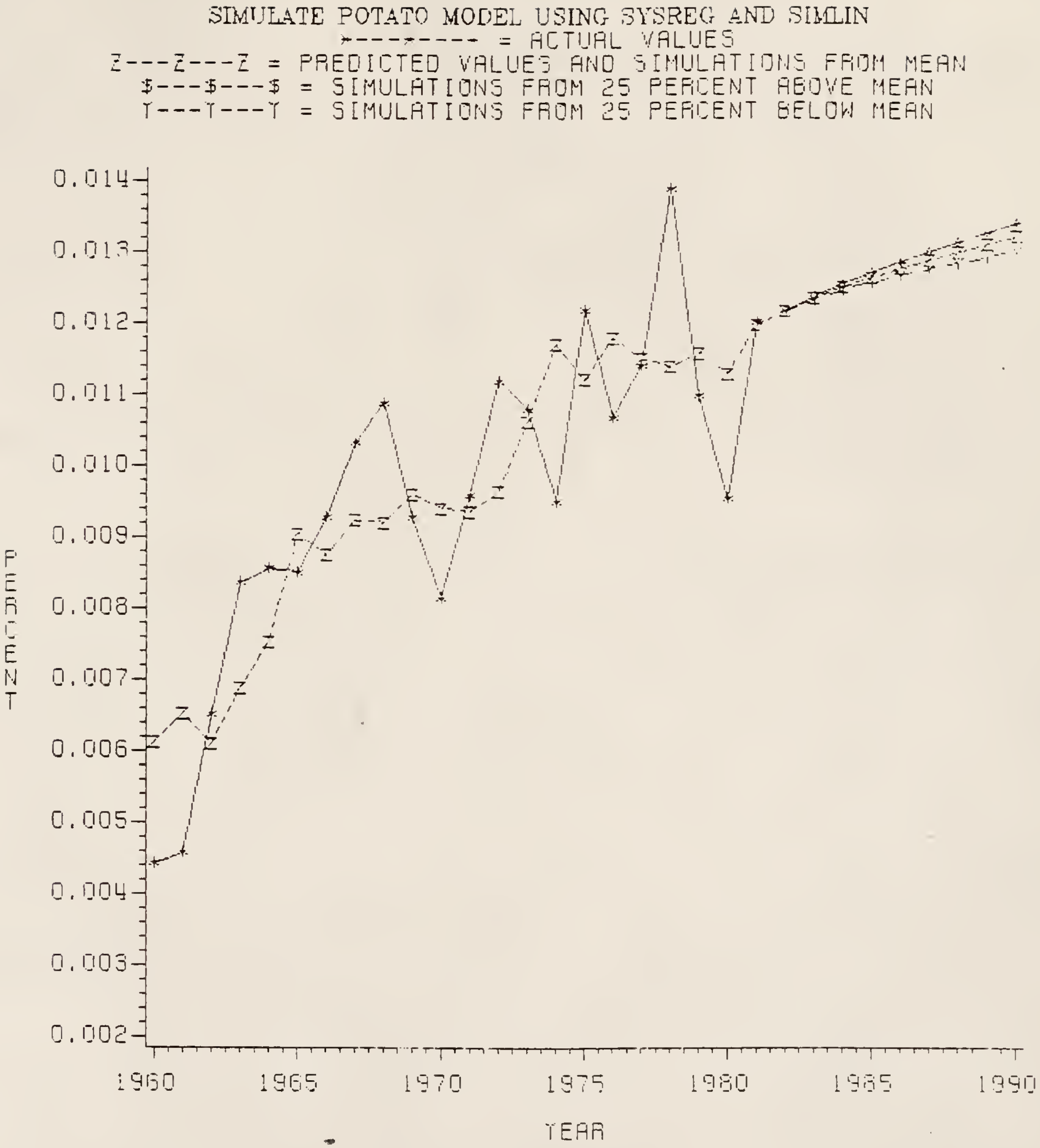


Figure 7.4. Actual, Predicted and Simulated Values for Advertising Sales Ratio

related. Sales of processed potatoes are most likely to decline when there are considerable shortfalls in production. Advertising expenditures, on the other hand, are less likely to fluctuate with production as these are planned and budgeted beforehand.

Long-term multipliers for the traditional demand shifters reveal that these variables have positive and sizeable carryover effects on ASR. This suggests that these demand shifters influence planned advertising expenditures on processed potatoes. That is, both current and future advertising expenditures are influenced by current changes in these demand shifters.

As shown in Figure 7.5, the potato industry experienced erratic capacity changes during the 1960-70 period. Percent changes in capacity turned downward from 1962 to 1964, surged upward in 1965 and 1966, fell sharply in 1967, and then changed moderately the remaining years. These erratic changes are predicted poorly, but the downward trend is traced. Sharp downturns in predicted values for 1978-81 are probably attributable to soaring interest rates for this period. Some percentage increase in capacity was actually realized as potato processors either were not greatly impacted by increases in capital costs or were committed to these expenditures before the upward surge in capital cost. Performance for this reduced form is unsatisfactory as a RMS percent error of 67.6 is observed.

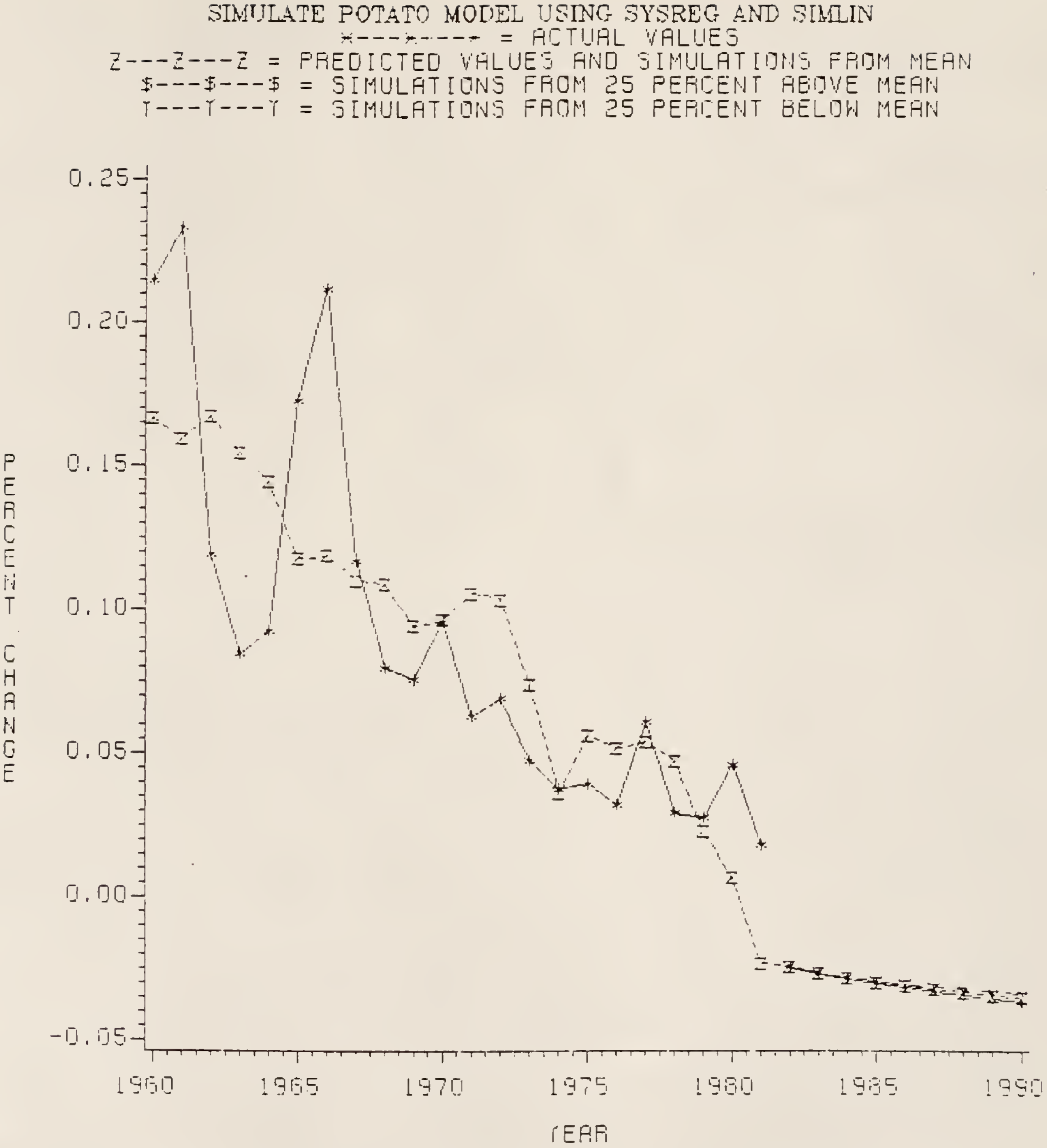


Figure 7.5. Actual, Predicted and Simulated Values for Changes in Processing Capacity

Examining the long-term multipliers, a 1 percent increase in dispersion of potato production (GD) leads to .0013 percent increase in CCA. A $1 increase in transportation cost (CT), on the other hand, causes a long-term decline in CCA of .0014 percent. Capacity therefore expands with dispersion of potato production, but declines with rising transportation cost. In other words, although processing plants are centered around raw potato production, raw production has become more concentrated because of increased CT.

As may be seen in Figure 7.6, utilization of processing capacities (UCA) rose sharply during 1961-64, fell drastically from 1964-67, and then rose sharply again from 1967-70. Recalling from Figure 7.5, these are approximate periods for which CCA exhibited similar but opposite patterns of change. During the above mentioned periods, UCA changed from a low of 40 to a high of 61 percent. These low rates suggest a period for which the industry adjusted from overexpansion.

While this reduced form shows low sensitivity to turning points, its performance as measured by the low RMS percent error of 7.9 is quite acceptable. As another measure of performance, simulation for the model was started in 1965 rather than 1960. A comparable level of performance was observed in terms of sensitivity to turning points and RMS percent error.

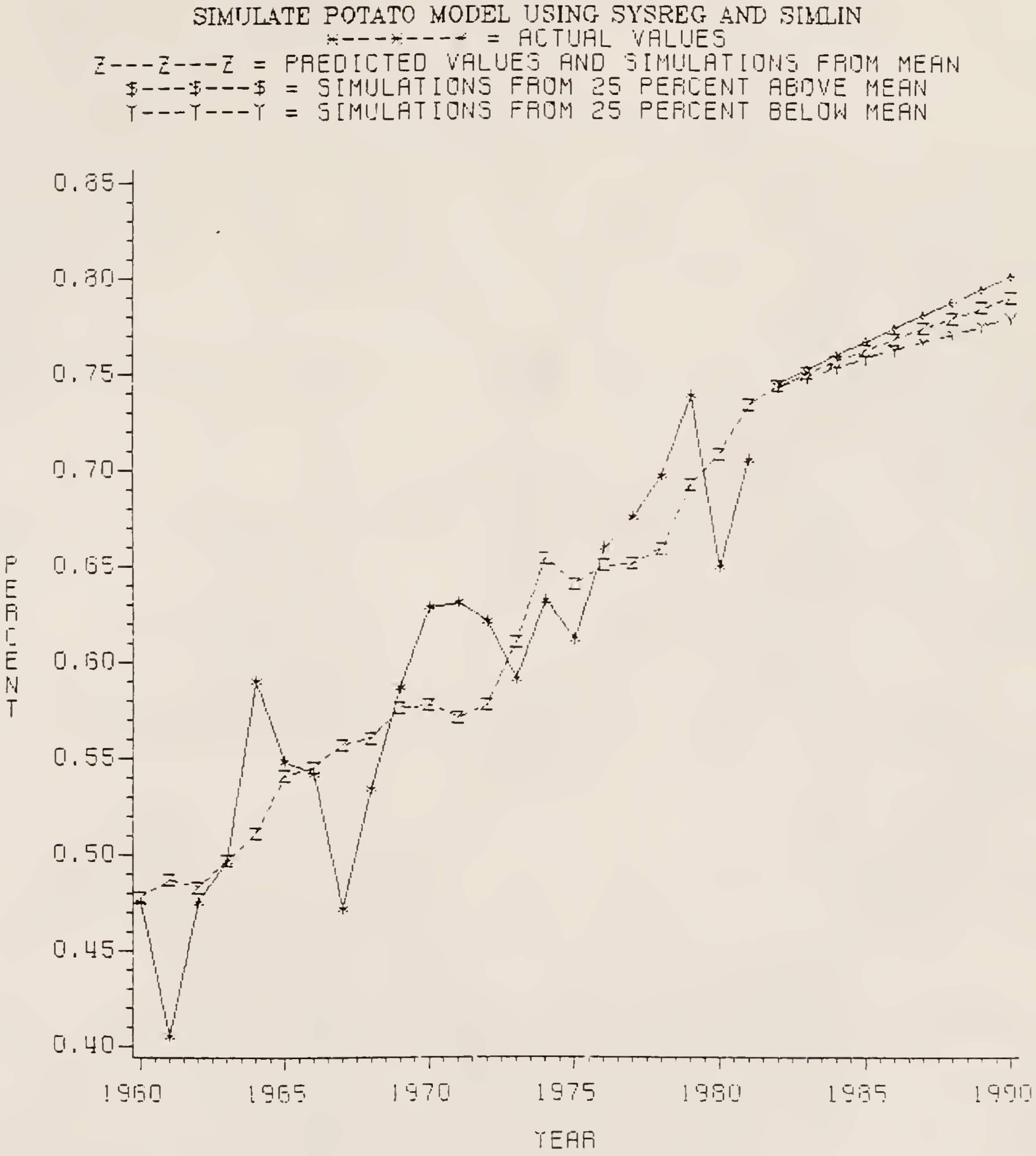


Figure 7.6. Actual, Predicted and Simulated Values for Utilization of Processing Capacity

The long-term multiplier shows that a 1 percent increase in GD leads to a .0024 percent decline in UCA. Although there may be a positive relationship between plants and production dispersion, there is an inverse relationship between the number of plants and their utilization rates. Smaller plants in essence are operated at lower capacities than larger ones.

Reduced and Final Forms for Market Equilibrium Equations

As depicted clearly in Figure 7.7, the reduced form estimating raw potato production (QRP) performs exceedingly well. Actual production exhibits considerable variation and wide fluctuation from year to year. Yet, nearly all turning points are predicted and there are minimal discrepancies among actual and predicted values. It should be emphasized that QRP is estimated in its structural form as a function of predetermined variables only. Such procedure greatly improves the precision of estimation since no predicted values from the first stage are included in the second and third stage regressions. These differences in estimating procedures notwithstanding, estimation of these erratic production changes with considerable precision speaks to the sensitivity of this reduced form in tracing extreme volatility.

Performance for this reduced form is exceptional not only for its satisfactory duplication of turning points but also for its low RMS percent error of 4.7 (Table C.7). Pindyck and Rubinfeld (1976) note that frequently a model

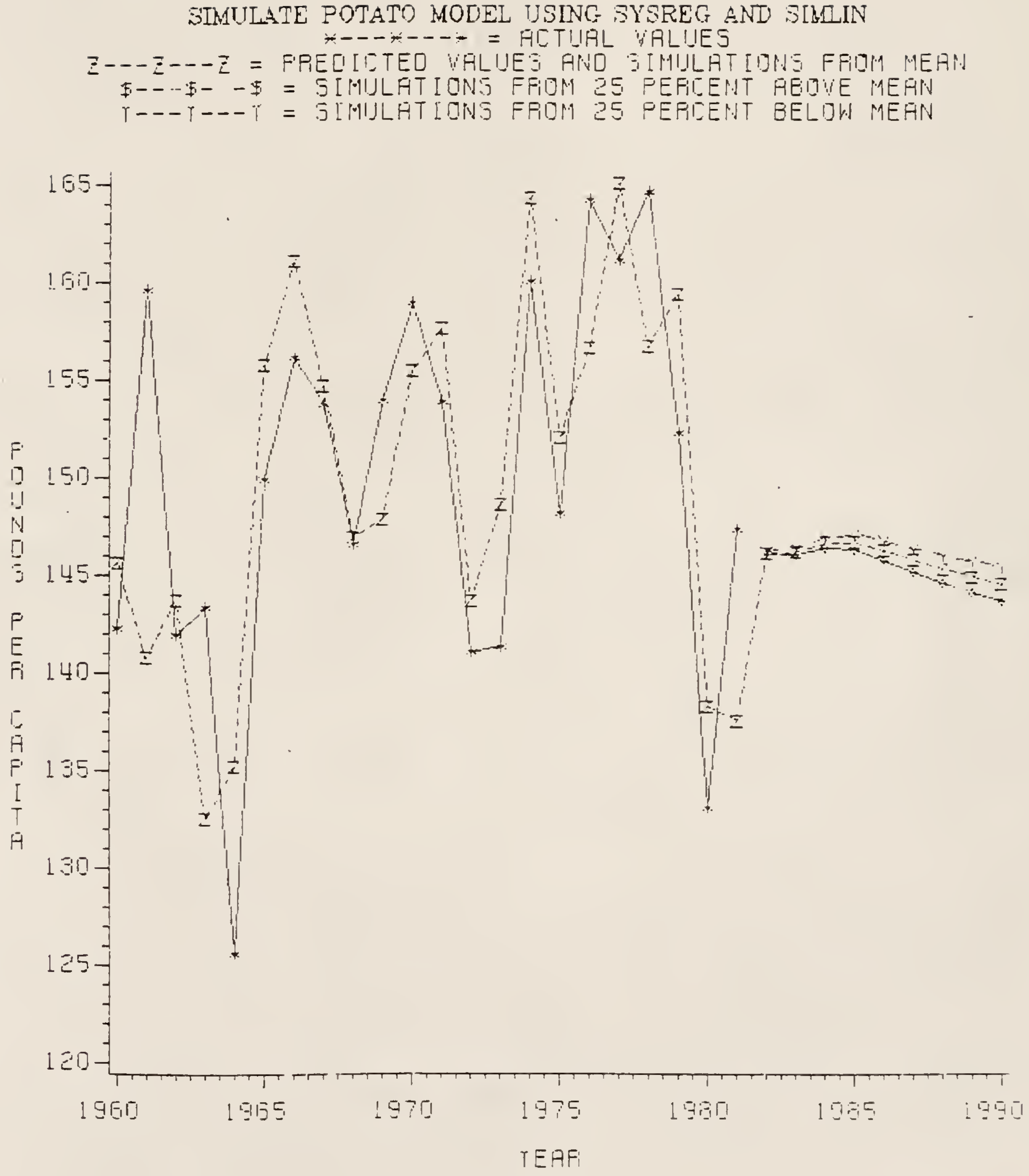


Figure 7.7. Actual, Predicted and Simulated Values for Production of Fresh Potatoes

which duplicates turning points will exemplify high RMS errors, and vice-versa. They contend that a model with both high sensitivity to turning points and low RMS error, as observed here, is indeed characteristic of good performance.

A glance at Figure 7.8 reveals that the reduced form for utilization of fresh potatoes (UZF) traces the downward trend in actual consumption extremely well. Although several turning points are not called, deviations among predicted and actual values represent a RMS percent error of only 7.4. The corresponding RMS error is 4.2 as measured against mean consumption of 62.7 pounds per capita. Additionally, variation in the initial simulation period did not lead to lower performance as measured by RMS error and turning point sensitivity. On balance then, performance for this reduced form seems most acceptable.

Several exogenous variables have significant long-term impacts on UZF. Contrary to our economic hypothesis, increased produce sales (GC) at supermarkets have an adverse long-term impact on UZF. A 1 percent increase in GC causes future UZF to fall by .3 pounds per capita. A smaller but significant effect is realized from a 1 percent increase in FF; UZF declines by .18 pounds. The long-term effect of a 1 percent increase in WN is a .43 pounds decline in UZF. A comparison of UZF with UZP shows that these aforementioned variables have a larger adverse impact on UZF than a positive impact on UZP. Thus, some of the factors leading to a decline in consumption of fresh potatoes are not

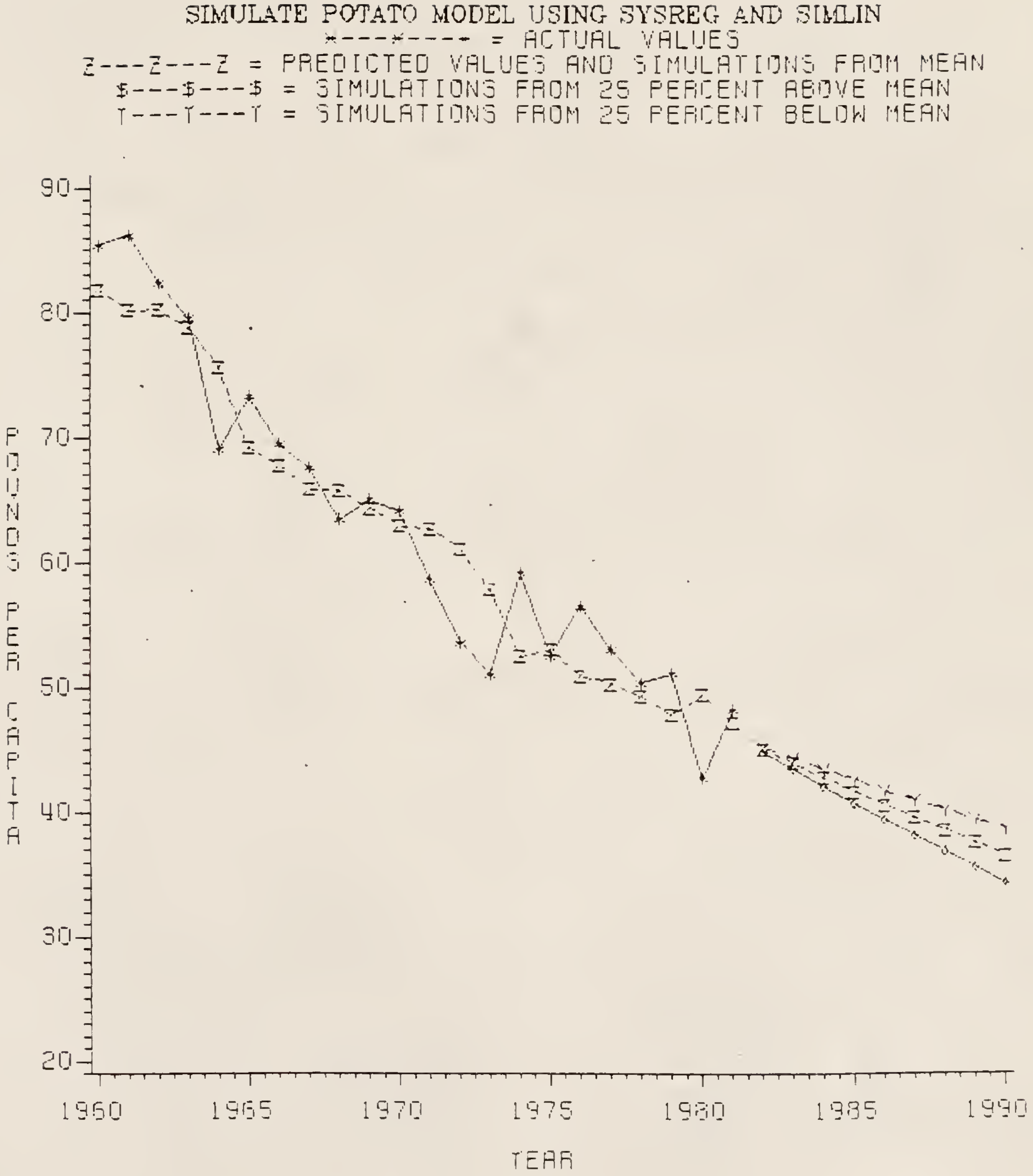


Figure 7.8. Actual, Predicted and Simulated Values for Utilization of Fresh Potatoes

leading to an equal or similar increase in consumption of processed potatoes.

The reduced form for processed potatoes depicted in Figure 7.9 picks up the upward consumption trend and calls many turning points. In modelling consumer behavior toward consumption of processed and fresh potatoes, one may hypothesize greater fluctuations in the former than latter and attempt to account for these in the model. One reason for such hypothesized differentials would be oscillating advertising expenditures on processed potatoes. Having integrated this hypothesized pattern of consumer behavior into the model, then it readily follows that the reduced form for UZP should pick up turning points more accurately than the reduced form for UZF. Indeed this pattern is observed.

Despite the greater sensitivity of this reduced form to turning points, its RMS percent error of 7.8 is actually higher than that for UZF. Relative to UZF, a lower RMS error of 4.1 is observed, but this error also corresponds to a lower mean per capita consumption of 59.9 pounds. On balance though, performance is highly acceptable as measured by the low RMS errors and the turning point sensitivity.

Examining multipliers, several variables impacting both UZP and UZF have larger carryover effects on the former than latter. That is, long and short term multipliers for UZF are often insignificant, but quite significant for UZP. For example, the short and long term effects of a 1 percent

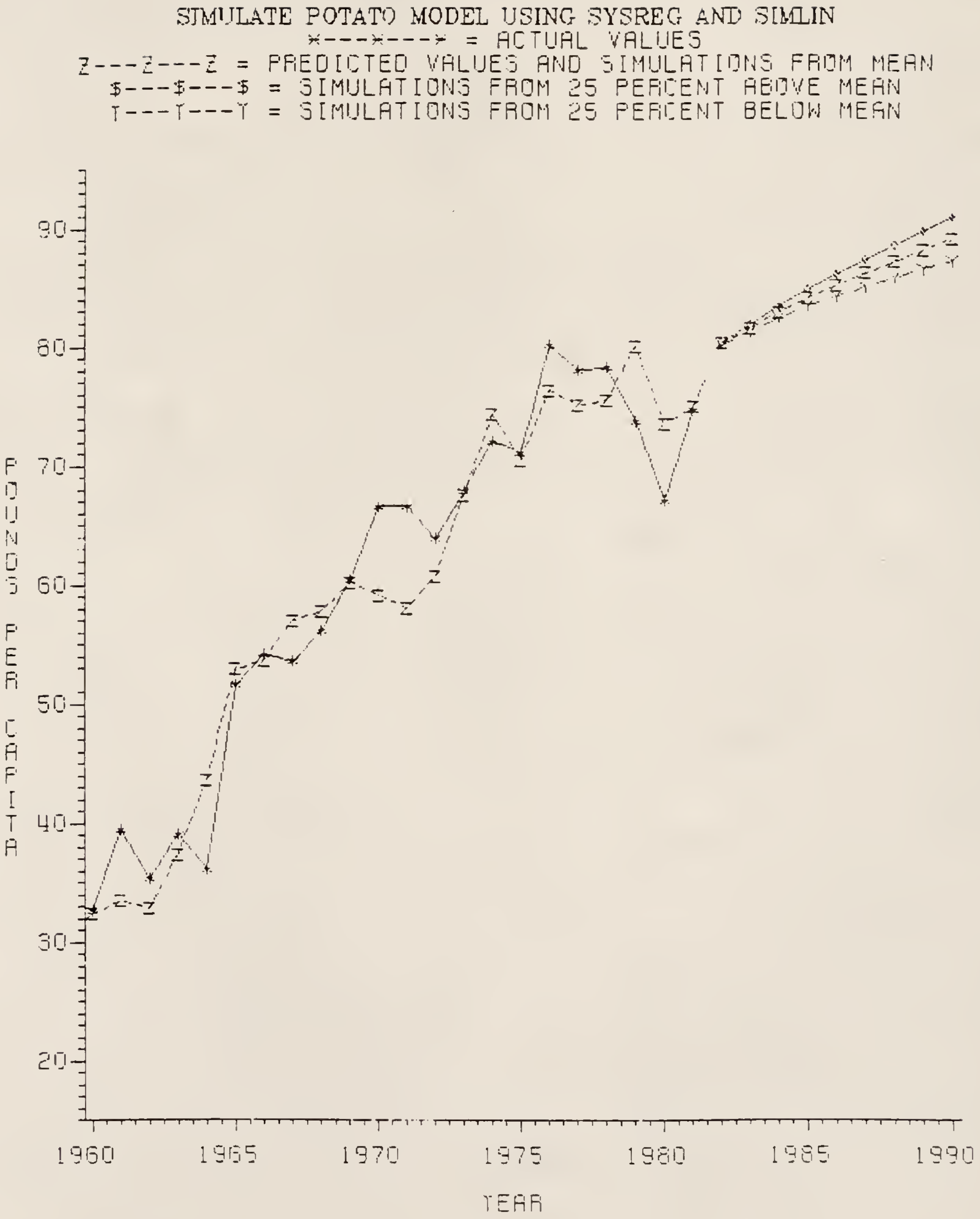


Figure 7.9. Actual, Predicted and Simulated Values for Utilization of Processed Potatoes

increase in GC are increases of .20 and .23 pounds respectively in UZP; a 1 percent increase in WN, by comparison, leads to short and long term increases in UZP of .29 and .34 pounds. These same variables have larger absolute effects on UZF but these effects are immediate with little carryover.

All nine reduced-form equations discussed heretofore have traced all trends, called many turning points, and predicted values approximating actual values. Subsequent equations, depicted in Figures 7.10--7.16, exhibit a less satisfactory level of performance. Much of this decline in performance is due to large fluctuations and high volatility of the underlying variables, mostly prices. It will be seen though that the model still performs well, particularly among variables with less extreme volatility. These patterns may have been predicted as they are characteristic of those observed for macro-econometric models (Christ, 1975; Fromm and Klein, 1976).

Figure 7.10 shows that the farm price of potatoes (FPR) exhibits high variance and large fluctuations from year to year. The price fell from $2.10 per hundredweight (cwt) in 1960 to $1.43 in 1961, increased by 1964 to $3.70, declined severely by 1967 to $1.87, rose sharply in 1973 to $3.73 and so forth. These price changes, depicted in percentages, are plotted against production changes in Figure 7.17. This figure establishes that each of the preceding price changes are associated with corresponding production changes which

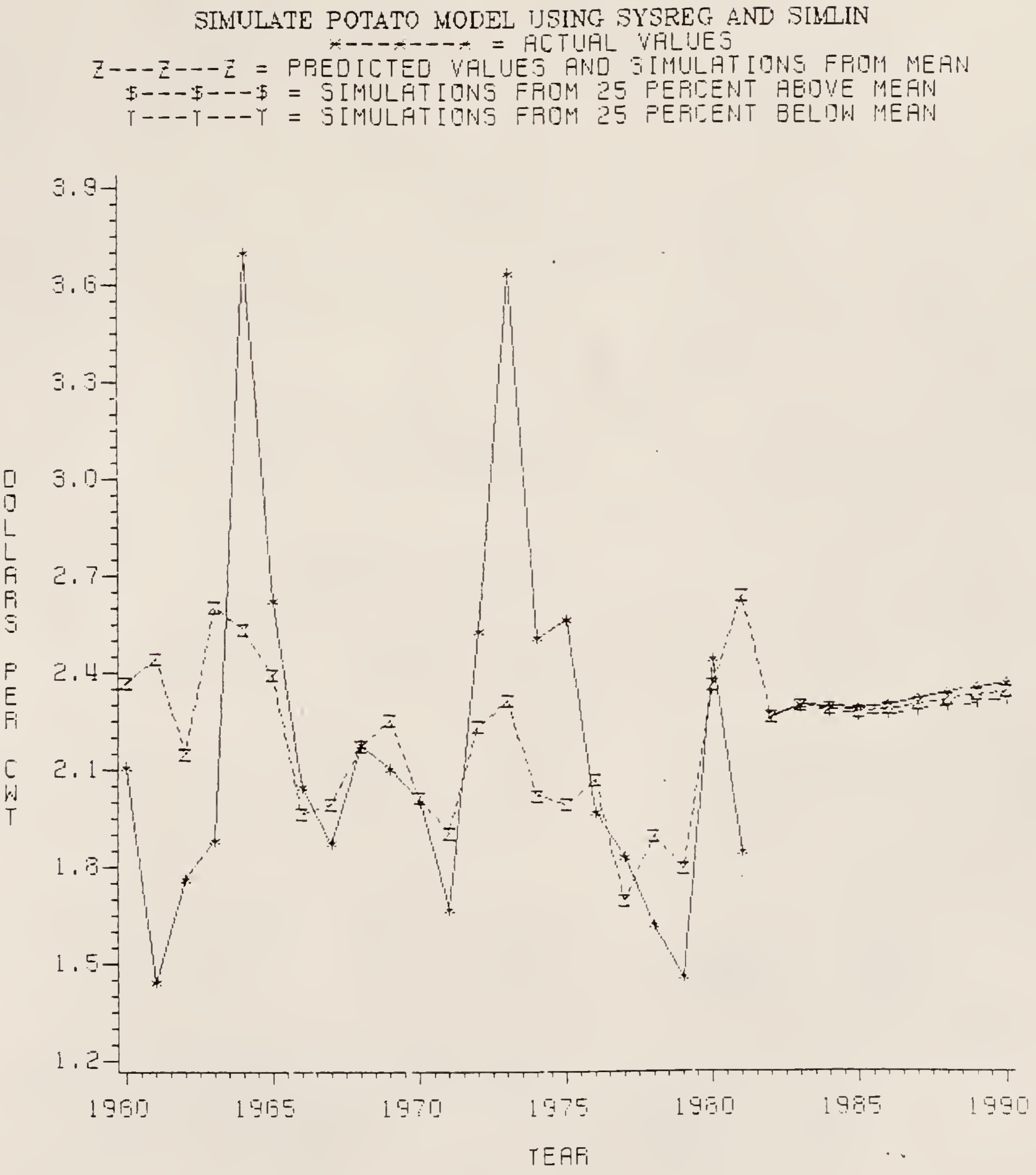


Figure 7.10. Actual, Predicted and Simulated Values for Farm Price of Fresh Potatoes

are invariably smaller and in the opposite direction. Modelling this relationship presents difficulties because production changes are often the result of weather as opposed to economic factors and the model does not completely reflect the response to these extreme changes.

Despite sometimes wide discrepancies among predicted and actual prices, the reduced form calls many turning points but invariably underestimates the magnitude of these turns. When prices change less dramatically, as during 1966-71, the reduced form shows a reasonable approximation of predicted and actual prices. This factor coupled with the reasonable RMS percent error of 24.7 suggests a level of performance which is acceptable given the underlying nature of the variable being explained.

Examining the multipliers associated with FPR, the long-term effect of potato substitutes (PS) is 2.5 times greater than its short-term effect. This reflects the low elasticity of supply of potatoes. That is, potato producers shift to production of substitute crops only gradually in response to price increases. As this shift occurs, potato production is diminished and price is therefore increased.

Unlike FPR which fluctuates widely from period to period, Figure 7.11 shows that WPP exhibits a continually downward but less fluctuating pattern of movement. Price falls from a high in 1961 of $10.94 to a low in 1980 of $6.37 per cwt. This path of change is traced very closely by the reduced form. Actual and predicted prices in 1981

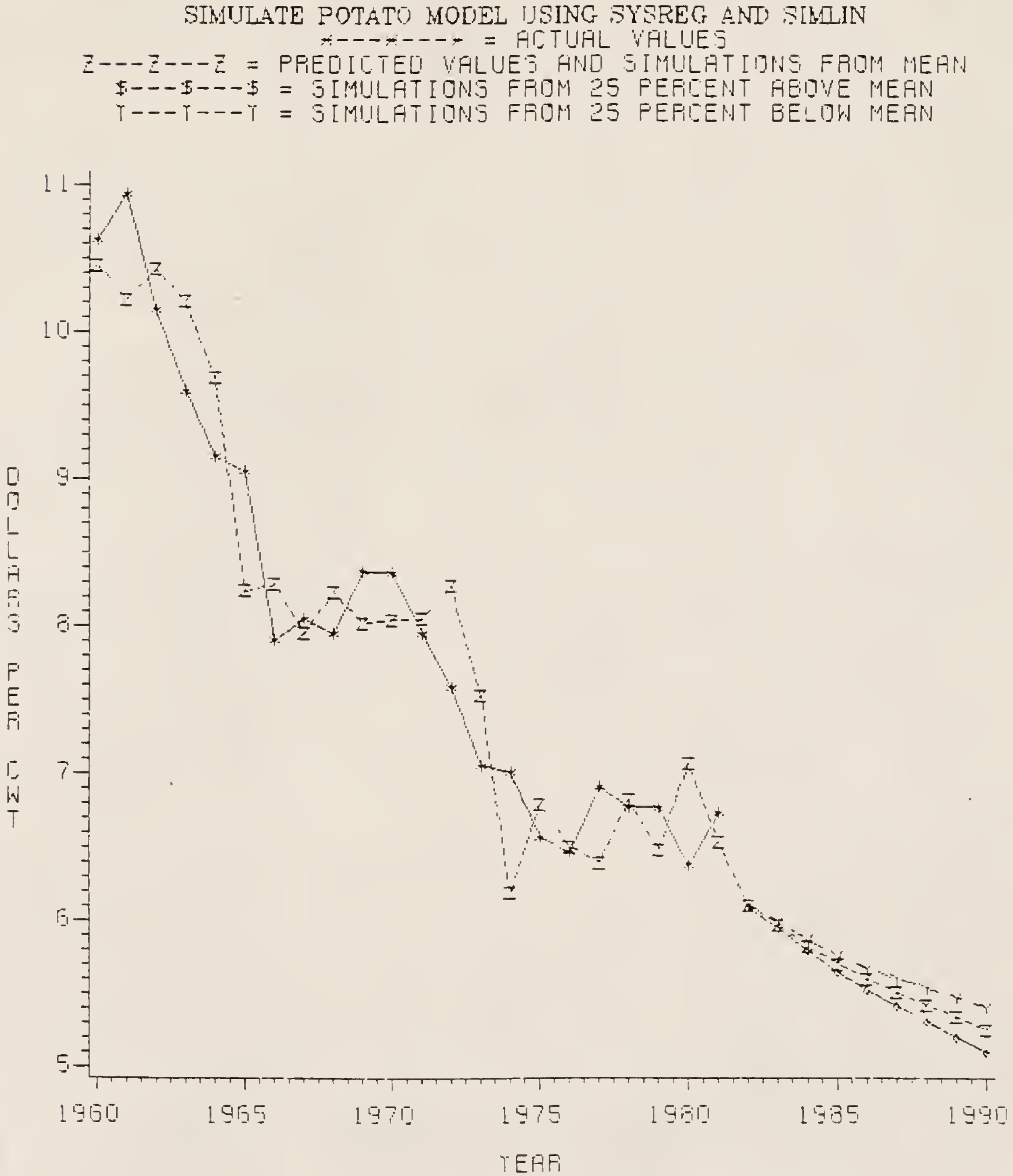


Figure 7.11. Actual, Predicted and Simulated Values for Wholesale Price of Processed Potatoes

are respectively $6.72 and $6.53 per cwt, a margin of $.19. By comparison, a $.17 margin exists for the beginning data point, 1960.

Performance for this reduced form is exceptional not only for its high sensitivity to turning points but also for its low RMS percent error of 5.9. Its corresponding RMS error is .46, but this is meaningful only in relation to the mean price of $8.2 cwt. Thus, performance for this reduced form is highly acceptable by all measures.

The multiplier effects are negative for all the exogenous variables which may be hypothesized to enhance demand and thereby prices of processed potatoes. Even rising income has a negative impact on WPP, though a positive effect on UZP. Suggested here is the fact that processed potato prices are determined more from endogenous than exogenous factors. Stated differently, WPP is probably more cost than demand related. Technological change (TR), for example, is shown to diminish WPP, perhaps through cost reductions. The model, accounting for the many factors influencing WPP, is shown to perform well on wholesale prices.

The retail price of fresh potatoes (RPF) depicted in Figure 7.12, is shown to register fluctuations similar to those exhibited by FPR. While changes in FPR were clearly linked to QRP, no consistent pattern exists between RPF and QRP (Figure 7.18). Occasionally there appear to be adverse but delayed price effects emanating from changes in QRP.

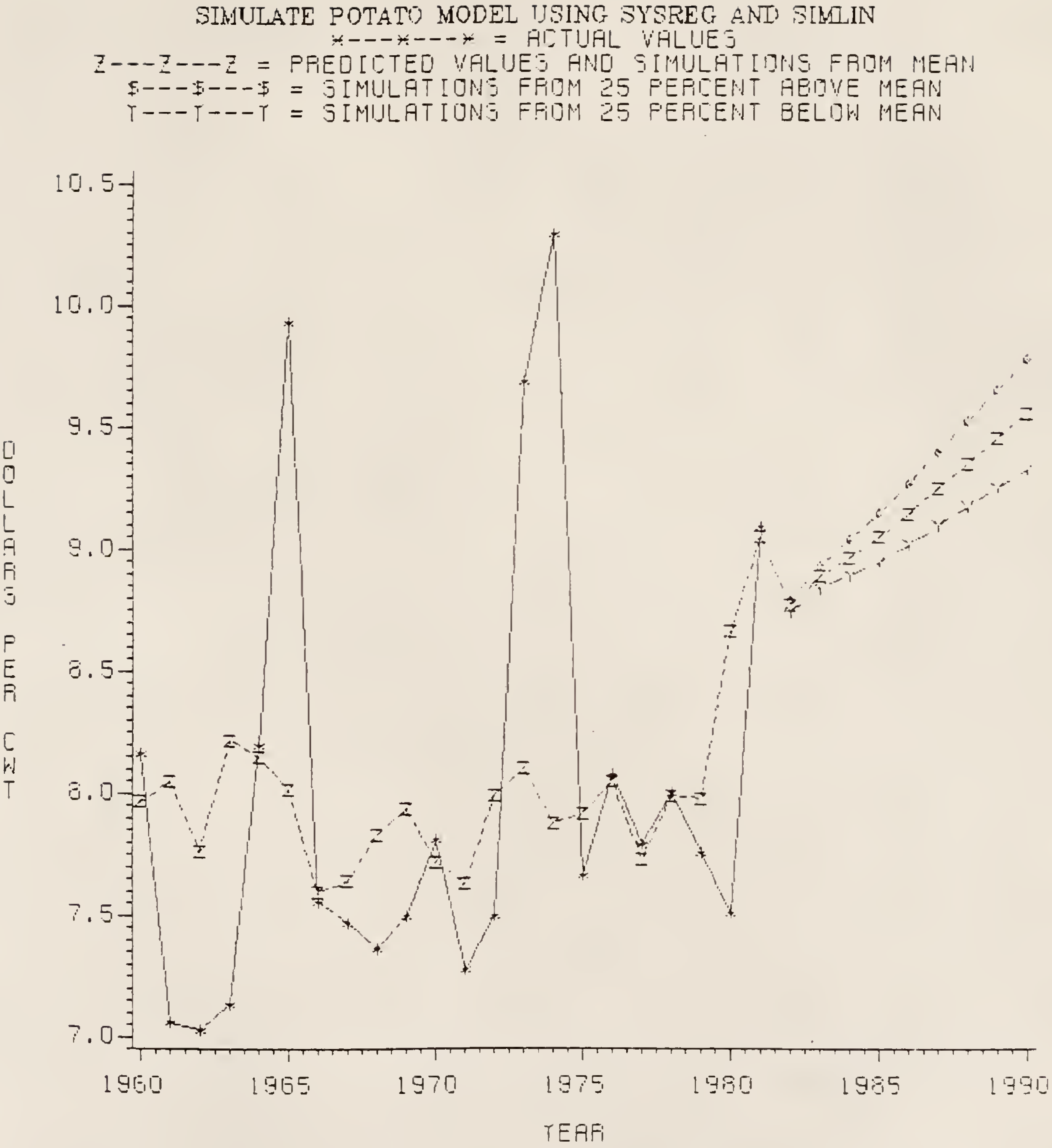


Figure 7.12. Actual, Predicted and Simulated Values for Retail Price of Fresh Potatoes

Although the reduced form for RPF greatly underestimates the magnitude of changes in RPF, it nonetheless calls most turning points. Despite these underestimations, a reasonably low RMS percent error of 9.8 is observed. Additionally, varying the initial simulation period from 1960 to 1965 did not lead to a lower level of performance. In light of these measures, performance for this reduced form is judged acceptable but stronger results are desired.

Multipliers for RPF are identical to those for FPR, except additional multipliers for RPF emanate from MC. Similarity of multipliers stems from the estimation of RPF as an identity of FPR plus a function of MC. Note that the long term multiplier for MC is identical to its short term value, thus indicating that all increases in MC are reflected immediately at the retail level.

A glance at Figure 7.13 reveals that the retail price of processed potatoes (RPP) has changed less erratically than that of RPF (all prices are expressed in real terms). The price exhibits a downward trend from 1960 to 1973, turns upward from 1973 to 1977, and then fluctuates capriciously thereafter. Despite the two relatively smooth trends, wide discrepancies exist between predicted and actual prices for these periods, with the most pronounced ones occurring from 1966-73. An observed inverse relationship between predicted and actual price for much of this period probably is due to the unexpected relationship between WPP and RPP. The wholesale price rises during much of this period; yet RPP

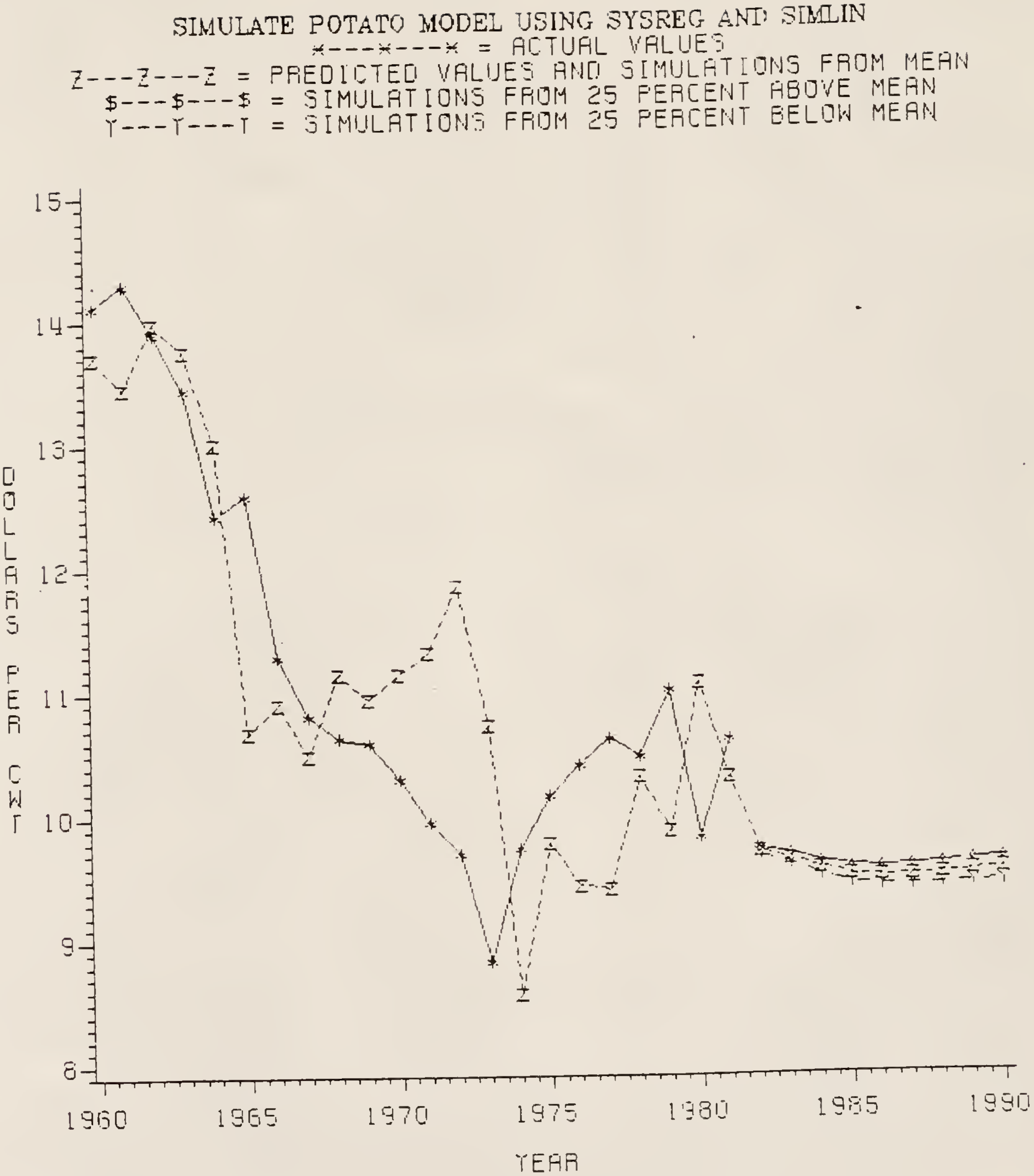


Figure 7.13. Actual, Predicted and Simulated Values for Retail Price of Processed Potatoes

falls. A probable cause of this anomaly is that a large proportion of frozen potatoes are reflected in wholesale prices but not in retail prices. With frozen potatoes becoming the dominant processed form during this period, it is conceivable that prices could have risen at the wholesale level while simultaneously falling at the retail level.

Despite the low sensitivity to turning points exhibited by this form, a relatively low RMS percent error of 10.0 is observed. The corresponding RMS error is 1.0, measured against a mean price of $11.2 cwt. A comparable level of performance is observed for a change in the initial simulation period from 196) to 1965. On balance then, performance appears to be at a statistically acceptable level.

Revealed from the multipliers is the fact that variables with long-term positive impacts on demand for processed potatoes have negative impacts on prices of processed potatoes. These relationships help establish the inverse relationship between demand and prices of processed potatoes. As an example, a 1 unit increase in expected growth (GR) leads to a .06 pound long-term increase in UZP but a $.009 cwt decrease in RPP. Similar multiplier effects are realized from all remaining exogenous variables, those that have negative impacts on UZP, of course, have positive impacts on RPP.

Just as wide discrepancies exist between predicted and actual prices of fresh potatoes at the retail and farm level, the spread of retail and farm prices (SPR) shows similar discrepancies. As shown in Figure 7.14, large fluctuations in SPR occur from year to year. From 1960 to 1964, SPR fell from $6.05 to $4.50, rose in 1965 to $7.30, fell sharply in 1966 to $5.51, and so forth (note that all prices are expressed in real terms). Capturing these fluctuations proved to be beyond the level of sensitivity of the model. However, a reasonable RMS percent error of 12.3 is realized. As may be seen, this reduced form predicts a slow-moving, upward trend. This trend reflects the marketing cost (MC) variable from which SPR is estimated in its structural form.

Depicted in Figure 7.15 are the predicted and actual values for the research and promotion tax (RPT). Although actual tax expenditures follow an erratic path, predicted expenditures call several turning points, though the magnitude of these turns are underestimated. This failure to capture the magnitude of the turning points results in a large RMS percent error. By this measure alone, performance for this reduced form must be judged inadequate.

Multipliers for RPT, it may be noted, are determined primarily from UZF and UZP. Whether an exogenous variable has a negative or positive long-term effect on RPT depends on the signs and relative magnitude of the associated multipliers for UZF and UZP. For example, the long-term effects of PN on UZF and UZP are -.116 and .113 respectively. From these two multipliers, it may be

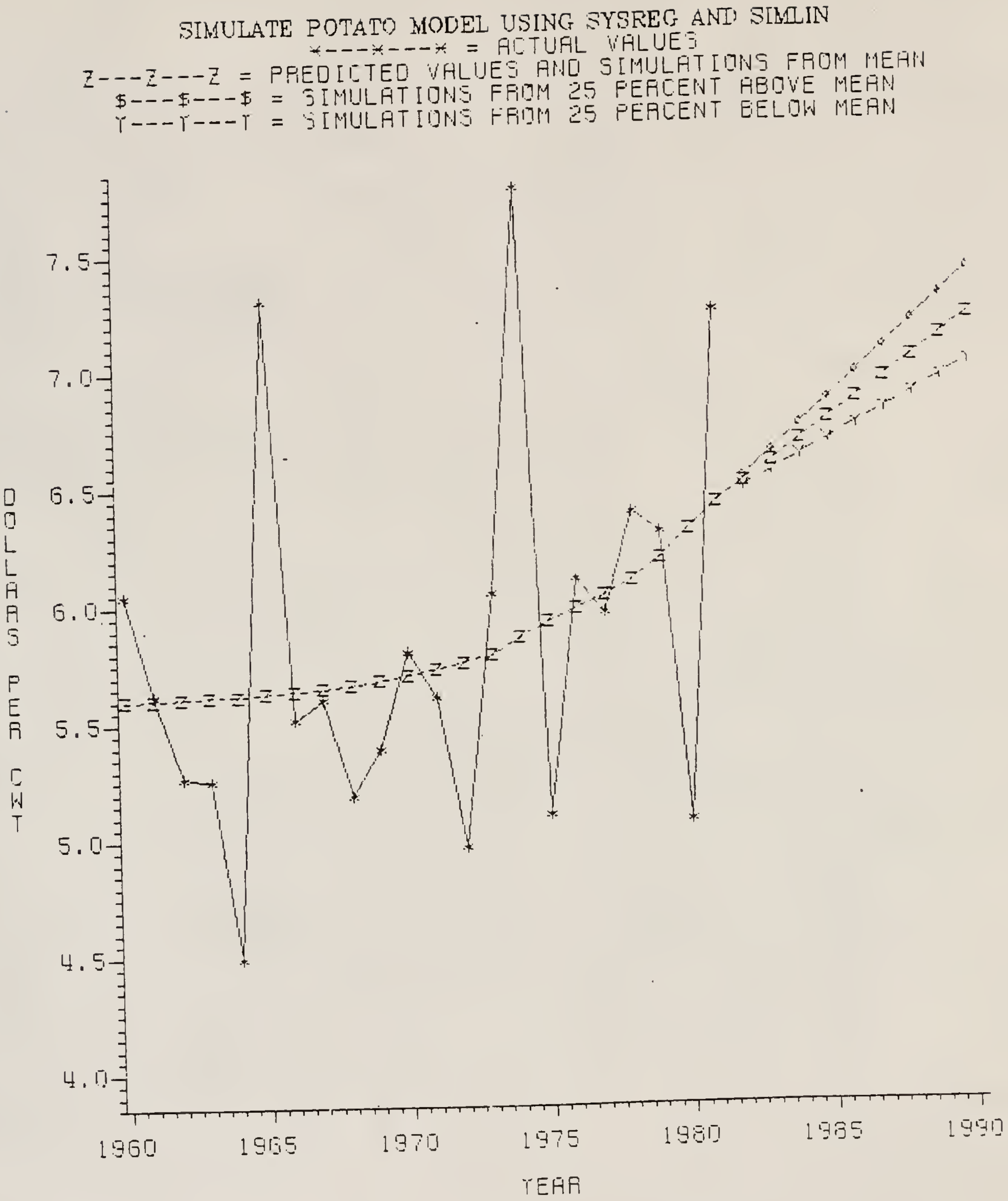


Figure 7.14. Actual, Predicted and Simulated Values for Spread of Retail and Farm Price

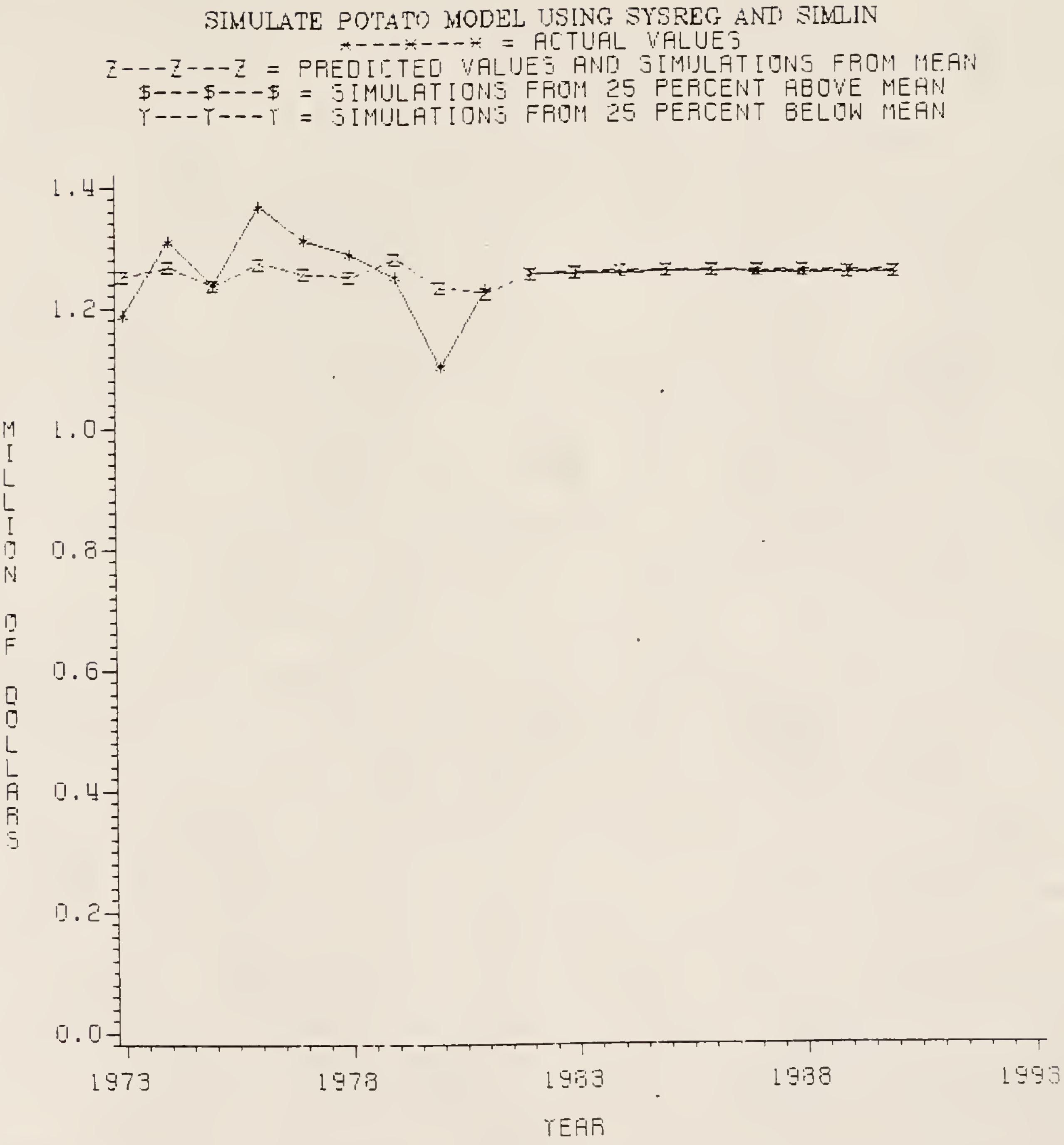


Figure 7.15. Actual, Predicted and Simulated Values for Research and Promotion Tax

inferred that PN will have a negative multiplier effect on RPT. In summary, RPT increases or decreases as demand (UZF and UZP) increases or decreases.

Figure 7.16 depicts the last reduced form equation. As can be seen, turning points for utilization of other potatoes (UZO) are called, but their magnitudes are invariably overestimated. This equation is estimated in its structural form as a residual of total utilization. Predicted values therefore partly reflect over and under estimation of fresh and processed potatoes. Deviations of predicted and actual values lead to a RMS percent error of 23.4. This error, while large as compared to that for some of the previously discussed variables, seems acceptable as a measure of performance.

A striking long-term multiplier effect is associated with potato substitutes (PS). Revealed here is the fact that a $1 per cwt increase in PS leads to a long-term decline in UZO of 28 pounds per capita. As UZO is comprised of potatoes for seed, feed, and losses through shrinkage, this multiplier indicates that these uses are greatly diminished as potatoes for more essential uses expand. It may also be noted that a 1 unit increase in geographic dispersion of potato production (GD) leads to a long-term increase of .17 pounds per capita in UZO. This multiplier confirm a popular viewpoint among potato specialists that increased size and specialization of potato farms lead to better potato utilization. Increased size and

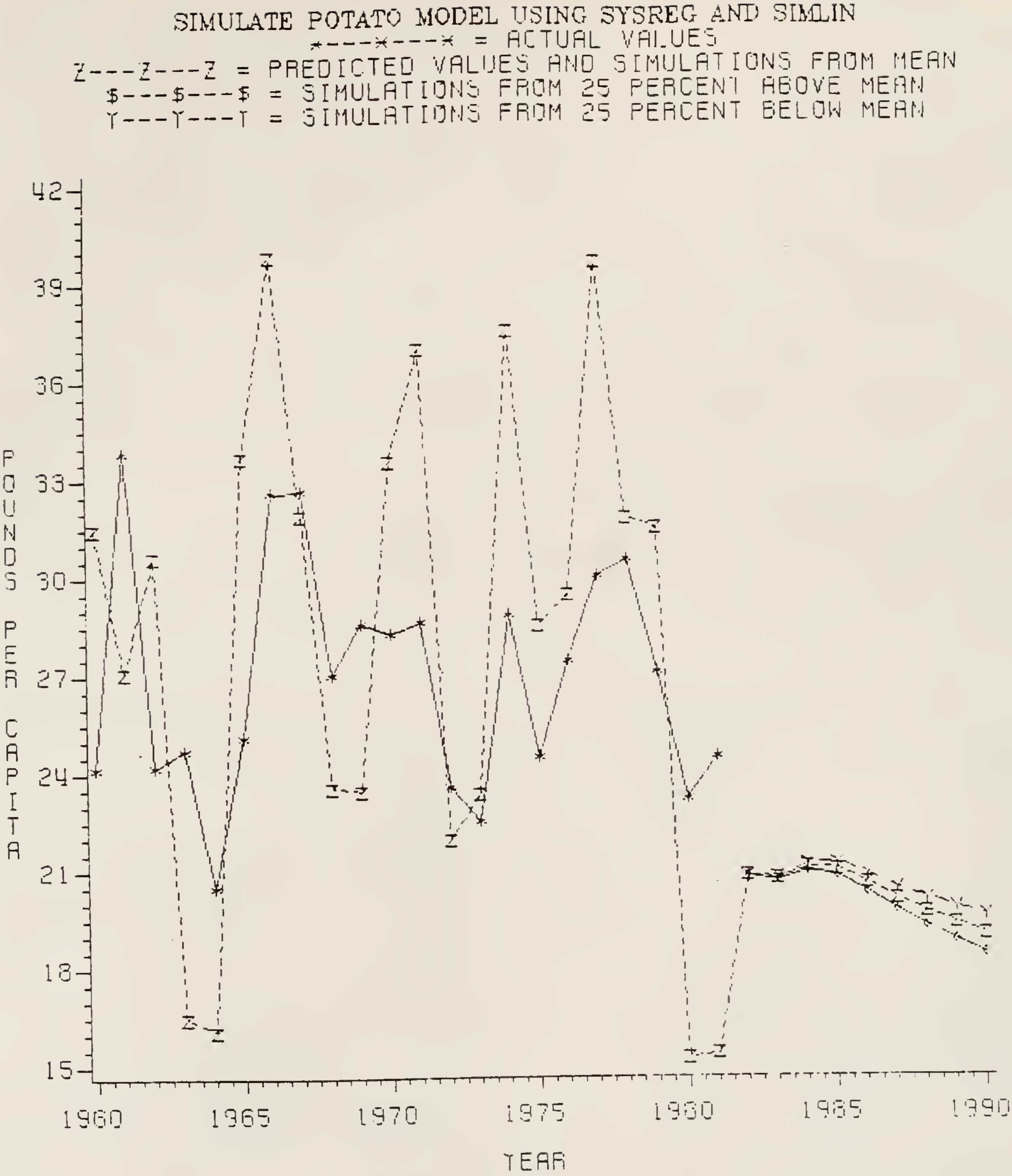


Figure 7.16. Actual, Predicted and Simulated Values for Utilization of Other Potatoes

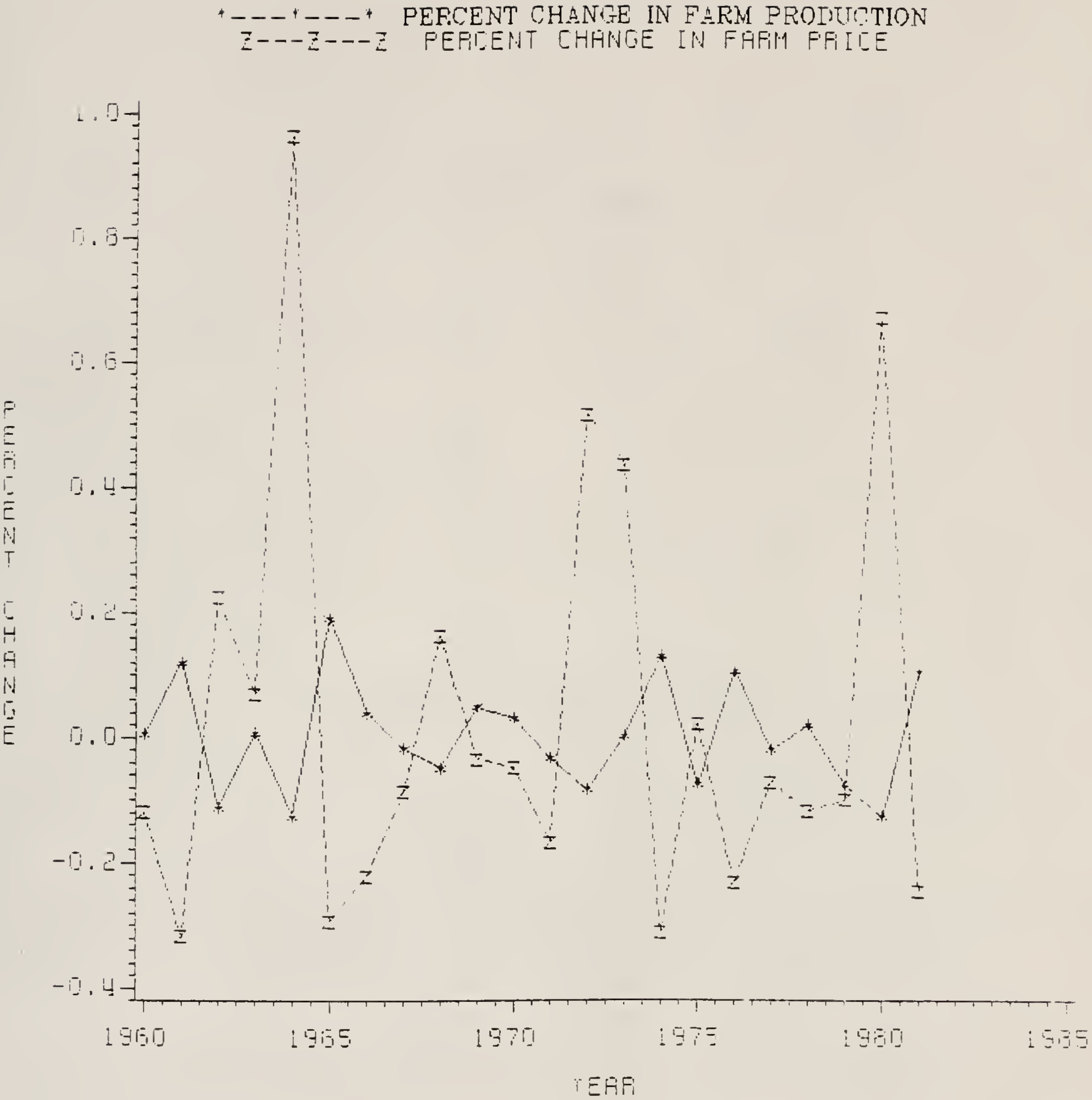


Figure 7.17. Percent Changes in Farm Price and Farm Production of Potatoes

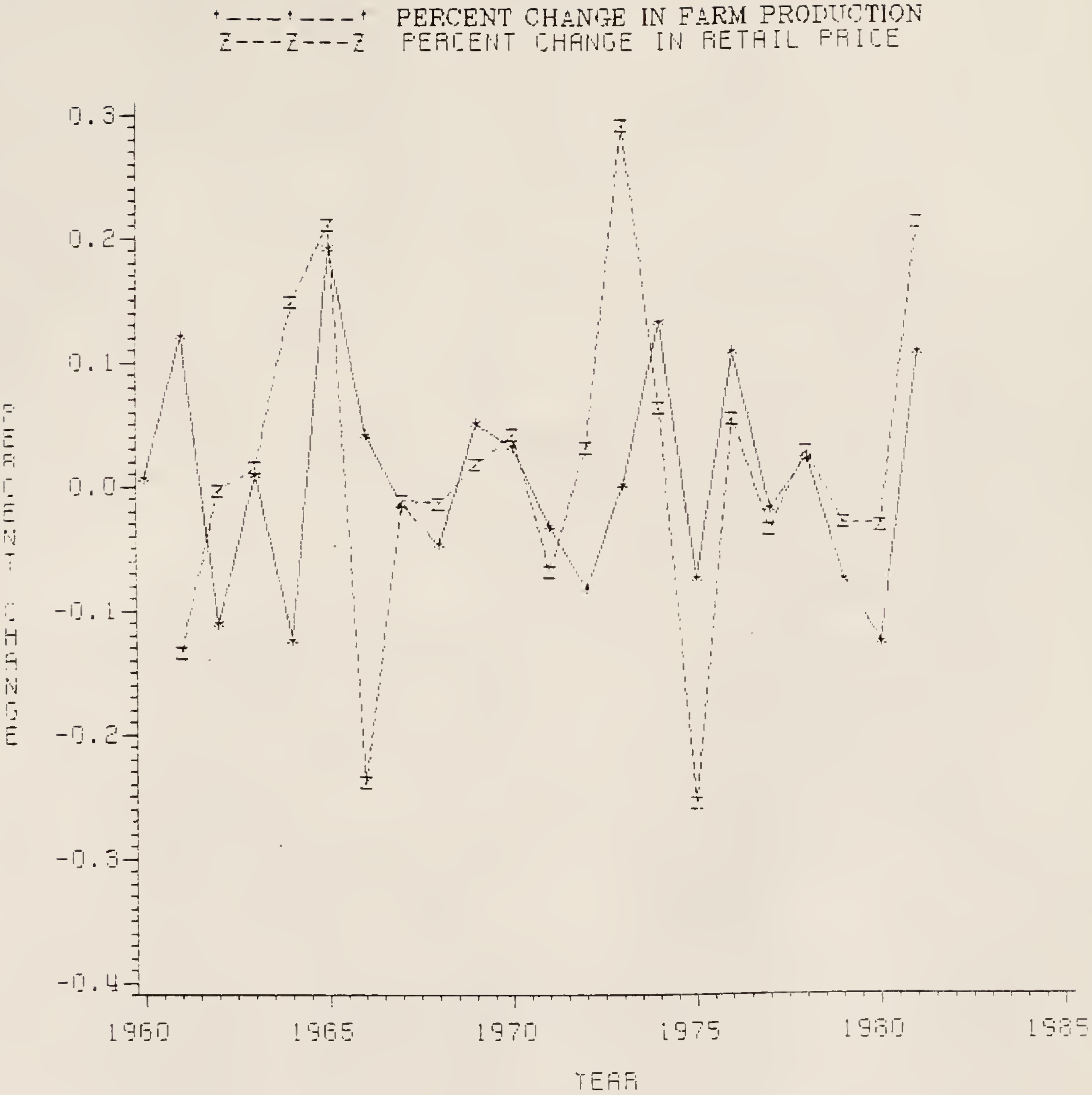


Figure 7.18. Percent Changes in Retail Fresh Price and Farm Production of Potatoes

specialization, of course, are assumed tantamount to increase concentration or less dispersion.

In summary, reduced forms perform well for several market equilibrium variables, especially those exhibiting mild fluctuations from period to period. Performance is exceptional for production of fresh potatoes despite capricious fluctuations. A considerable decline in performance is observed as the model predicts highly volatile prices, particularly prices of fresh potatoes at the farm and retail level. This performance though is characteristic of that observed for macroeconometric models.

Synopsis of Structural and Market Equilibrium Results

This econometric model of the U.S. potato industry performs well on both structural and market equilibrium equations. Measuring performance on the basis of RMS percent error, RMS error and sensitivity to turning points, it seems safe to conclude that structural equations exhibit a more satisfactory level of performance than market equilibrium equations. The structural equations exhibit less fluctuations and volatility than market equilibrium equations. With a high sensitivity to turning points exhibited by several reduced form market equilibrium equations, performance for this set of equations is also highly acceptable.

Viewing the six structural equations, it is quite clear that performance for concentration, and the number of processing plants is superior to that of the other four equations, irrespective of how performance is measured. The last four structural variables did, however, show greater fluctuations than the aforementioned variables; poorer performance for these variables may be due to intrinsic factors. As an example, changes in capacity (CCA) or increased capacity, although made in response to economic factors, may come on stream as economic factors are suggestive of diminished capacity. Such untimely responses are difficult to capture in the model because they are uncharacteristic of rational economic behavior.

Despite slippage in performance for the last four structural equations as compared to the first two, overall performance for these equations is well within a statistically acceptable level. In fact, given the complexity of the model and observed performances for macroeconometric models, a more sanguine conclusion would probably be that performance exceeds most statistically acceptable levels.

Performance in the market equilibrium sector may be separated according to (a) supply, (b) demand and (c) price equations. Despite large fluctuations in potato supply (QRP), the reduced form accurately predicts turning points and determines the sharpness or magnitude of these turns. Demand equations for fresh and processed potatoes show close approximation between predicted and actual values. However, erratic and large fluctuations in prices of fresh potatoes at the farm and retail levels are predicted with only reasonable accuracy. The inability of the model to more accurately predict these changes is hypothesized to result from large price responses emanating from small, yet unpredictable, production changes that the model simply does not adequately reflect.

Processed price equations, both wholesale and retail, are predicted reasonably well by their reduced forms. These prices, as compared to fresh prices, respond less erratically to production changes. Still, considerably fluctuations are observed with many of them being traced by the reduced forms. In summary, the model performs well in the market equilibrium sector despite its lack of complete sensitivity to erratic price changes.

Model Forecasts

Theory of Forecasting

Forecasting, according to Intriligator (1978), is the process of predicting values of variables outside the available sample of data. Non-economic or nonscientific predictions can be based on expert opinions or beliefs. One may predict, for example, that his feelings tomorrow will be identical to his feelings today. Such prediction or forecast, although frequently correct, lack a theoretical basis comparable to that which underlies econometric forecasts. Intriligator argues that reduced forms from which econometric forecasting is done are reflections of sound, well-developed economic theory as embodied in the structural-form equations. The discussion which follows will therefore be limited to econometric forecasting.

Econometric forecasting, as discussed here, refers strictly to forecasting from reduced forms which incorporate all parameters and variables emanating from the structural form of the model. Pertinent information emerging since the development of the model may be used to adjust parameters, errors terms, or exogenous variables. In fact, incorporating these factors together with those inherent in reduced forms is what makes econometric forecasting superior to other methods of forecasting (Intriligator, 1978). Forecasting from dynamic econometric models though, as is done here, is beset by the infancy of dynamic economic theory (Harvey, 1981).

Forecasts of endogenous variables, of course, are most often based on, or derived from forecasts of exogenous variables. In the present model, exogenous variables are forecasted to change at (1) their mean rate of the last five years of the data period (moderate growth), (2) twenty-five percent above mean (rapid growth), and (3) twenty-five percent below mean (slow growth). One exogenous variable, cost of capital (interest rate), is adjusted downward to reflect its current trend. No adjustments are made to parameters, intercepts or errors terms as these are unwarranted by prevailing information.

Forecasts of the endogenous variables from the three growth scenarios of the exogenous variables, depicted in

Figures 7.1 through 7.16, are reflections of the reduced forms expressed in equation 7.4. This equation shows that the forecasts reflect the economic theory embedded in the structural parameters, Γ , Π_1 and Π_2. Some additional information on econometric forecasts is also revealed from this equation. The endogenous variables are conditional upon predicted values of future exogenous variables, the coefficient matrices, and current endogenous variables. To see this, consider a one period forecast horizon as reflected in equation 7.6 below.

$$(7.6) \quad \hat{Y}_{t+1} = Y_t \hat{\beta}_1 + \hat{X}_{t+1} \hat{\beta}_2$$

This equation is a rewrite of equation 7.4 where $\hat{Y}_{t+1}$ is predicted Y, $\hat{X}_{t+1}$ is predicted X_1, $\hat{\beta}_1$ and $\hat{\beta}_2$ are the previously estimated coefficient matrices. Once the exogenous variables are known, a subsequent ex-post forecast can be made and compared with the ex-ante forecast. These aspects of econometric forecasting, notes Intriligator (1981), set it apart from other methods of forecasting.

Structural Equations Forecasts

All forecasts reflect a declining prime interest rate, rather than a soaring rate reflective of the 1976-81 period. Though the current market rate is 11 percent, a significant decline from the 18.8 percent of 1981, it is assumed here that this rate will be reached near the end of the forecast horizon, 1990. This should not be a gross distortion as the current rate is likely to show upward and downward movement during this horizon--perhaps averaging that predicted for the midpoint of the horizon.

A glance at the forecasts for processed plants (NPP) in Figure 7.1 shows that plants will differ significantly depending on the prevailing scenario. Higher rates of growth of exogenous variables lead to greater losses of plants. Although only three growth scenarios are reflected here, it should be obvious that changes between a plus and minus twenty-five percent of the mean rate are also inferable though not depicted.

Forecasts of NPP are influenced significantly by minimum efficient size of plants (MS). As MS increases, allowing for the same production in fewer plants or greater production in the same plants, a decline in NPP seems logical. As noted earlier, an increase of 1,000 pounds per hour in processing capacity leads to a long-term decline of 1.56 plants. Assuming MS together with the other exogenous variables changes at its mean rate throughout the forecast horizon, approximately 56 plants would be processing potatoes in 1990. This represents a loss of 174 plants from the 1981 total of 221. Though significant, it should be emphasized that the loss for the comparable 1971-80 period was 144 plants. With slower growth rates as occurred during the most recent recession and the possibility of other recessions emanating from persistent deficits, forecasts along the slow growth path may be more characteristic of the future. Under this scenario, roughly 90 processing plants will exist in 1990.

Figure 7.2 reveals that concentration among the top four potato processors is expected to increase but it will show little variations among the growth scenarios. Concentration is forecasted for 1990 to be in the range of 75.3 to 77.1 percent. As a measure of change, both predicted and actual concentration in 1981 amounted to 71 percent. Though no exogenous variable has a dominant multiplier effect on concentration, it is significant to note that a 1 unit sustained increased in geographic dispersion of potato production (GD) would cause future concentration among the top four potato processors to fall by .07 percent. Since GD declined consistently during the data period, this would suggest that this variable aided the growth of concentration. Indeed all but four of the twenty exogenous variables have positive impacts on CRP.

Just as concentration exhibits only slight variations under alternative growth scenarios, price cost margins (PCM) show a similar but downward pattern of movement. As depicted in Figure 7.3, forecasts for PCM show a decline from its predicted 1981 value of \$4.03 to a low of \$2.72 under the high-growth scenario and a high of \$3.08 under the slow-growth scenario. It may also be noted that the predicted 1981 value from which the forecasts are based differs considerably from actual PCM. If, for example, the predicted 1981 value is off by one period, then the decline in PCM, magnitude as opposed to rate, is likely to be less than those projected for the forecast horizon.

Multipliers for PCM reveal at least one interesting phenomenon. Increases in fast food sales (FF), reflecting increases in consumption of processed potatoes, have a positive long-term effect on CRP, but a negative effect on PCM. Indeed a 1 percent sustained increase in FF leads to a .007 percent increase in CRP, but a .002 cents per cwt decline in PCM. This suggests that increased concentration among potato processors has not led to increased margins. In fact, rising CRP may have had a dampening effect on margins. This analogy is not limited to just FF, but applies to total away-from-home food sales (TF) as well.

Another contrasting multiplier is that for cost of capital (CK). A sustained increase of 1 unit in CK will cause future CRP to increase by .20 percent, but will cause PCM to fall by .05 cents per cwt. Suggested here is the fact that larger firms will likely supply markets gained from smaller firms at no increased cost. That is, markets held by smaller firms exiting the industry because of increased CK are served by larger firms at the same or lower prices.

Forecasts in Figure 7.4 reveal that advertising sales ratio (ASR) are projected to lie within a narrow interval for the three scenarios. Note that the predicted 1981 value equals its actual value. This fact should enhance the expected accuracy of the forecasts. Irrespective of the growth rate of exogenous variables, ASR is forecasted to be 1.3 percent in 1990. This is an increase of 8 percent from the 1981 predicted and actual value of 1.2. It should not be inferred from these forecasts that only nominal increases will occur in advertising expenditures for processed potatoes. Indeed total advertising expenditures increased from $27 million in 1980 to $37 million in 1981, an increase of 37 percent. Yet ASR increased only .2 percent because of concurrent increases in sales.

With ASR forecasted to increase at nominal rates, no dominant multiplier could have been anticipated. As the price of potato substitutes (PS) increases, ASR declines. This suggests that potato processors have fewer economic incentives to advertise when PS is rising because there are built-in incentives for increased consumption of processed potato. These factors are reflected in the long-run multiplier for PS of -.0002.

As depicted in Figure 7.5, negative changes in CCA are forecasted throughout the horizon. This though is reflective of the underlying linear model and some peculiarities pertaining to the measurement of CCA. That is, by definition CCA will become increasingly smaller under constant additions to total capacity. These smaller changes, while reflected as negative changes during the forecast horizon, are appropriately declining rates of positive change. Given the discrepancy between the 1981 predicted and actual values, it seems safe to conclude that the actual magnitude of decline will be considerably less than that forecasted.

Examining the multipliers for CCA, a sustained increase of 1 percent in CK causes future CCA to decline by .005 percent. Given the present downward trend in CK, which is reflected in these forecasts, potato processors are likely to be more inclined to expand CCA in response to rising UZP than during previous periods of soaring CK. Technological change (TR) also has a significant multiplier effect on CCA. Future CCA will change by .0002 percent for each one unit of sustained increase in TR. Technological changes, of course, will be accompanied by changes in other exogenous variables. Ultimate changes in CCA will therefore depend on the influence of variables with both negative and positive impacts.

Figure 7.6 illustrates that the forecasts for UCA show considerable variation among growth scenarios. By 1990, UCA will reach 77 percent under the slow-growth scenario, 78 percent under the moderate-growth scenario, and 80 percent under the rapid-growth scenario. Given the 1981 actual value of 70 percent, the effects of the exogenous variables in increasing UCA should be quite apparent. It may also be noted that all long-term multipliers for UCA have impacts opposite of those for CCA. Thus, as CCA is retarded, UCA is expanded, and vice versa.

The long-term multiplier for CK shows a .005 percent increase in UCA for each unit of sustained increase in CK. A somewhat ambiguous result is the negative multiplier for PS. What is suggested here is the fact that potato production at both the farm and wholesale levels declines as farm producers switch from potatoes to substitute commodities. If increases in PS caused commodity switching only at the retail level, the expected multiplier effect of PS on UCA would be positive.

To recapitulate, forecasts for the six structural equations exhibit patterns of change that characterize those of the data period. While the precise rate of change of exogenous variables cannot be determined, forecasts from the three growth scenarios should provide realistic boundaries of future changes. Thus, planners or policy makers, especially those associated with the potato industry, may view these forecasts as growth patterns which evolve in the absence of endogenous policies to effectuate alternative changes.

Market Equilibrium Equations Forecasts

Forecasts for the market equilibrium equations, as a general rule, are probably less accurate than those for the structural equations because of greater fluctuations from period to period. This is especially true for the production and several price equations. As the two demand and two processed-price equations follow relatively smooth patterns, forecasts for these variables are probably more accurate than for other market equilibrium variables.

As can be seen in Figure 7.7, potato production (QRP) shows almost identical forecasts under all scenarios. One factor causing this is the limited number of exogenous variables impacting QRP. QRP is estimated in its structural form as a function of only predetermined variables. Hence, only these predetermined variables impact QRP in its reduced and final forms. During the forecast horizon, QRP increases from 137.4 pounds per capita to 143.5 and 145.3 pounds under the rapid and slow growth scenarios respectively. These smooth change patterns are unlikely to prevail given the erratic patterns of the past.

The long-term multiplier for PS shows that each $1 per cwt increase in PS effects a 30 pounds per capita increase in QRP. By contrast, a sustained increase of 1 unit in risk (RS) causes future QRP to decline .2 pounds per capita. The long-term multiplier effect of technological change results in an increase in QRP of .44 pounds. The related impact multiplier for PS generates an increase of 21 pounds in QRP for each unit of increase in PS. Large differences in the long and short term multipliers for PS suggest a carryover effect from period to period.

Although QRP shows little variation under alternative scenarios, Figure 7.8 shows that UZF is forecasted to range from 34 to 38 pounds per capita in 1990. The lower consumption rate, of course, emanates from the rapid growth scenario. Indeed growth of all but three exogenous variables serve to diminish UZF. Notable among these exogenous variables is fast-food sales (FF). The long-term multiplier shows that UZF increases .18 pounds for each 1 percent increase in FF. The corresponding impact multiplier is .17, suggesting that the effects of FF are immediate.

A $1 per cwt increase in PS leads to a long-term increase in UZF of 3 pounds per capita. A 1.2 pounds per capita increase is realized from the impact multiplier for PS. Long and short term multipliers for women in the labor force (WN), by contrast, are nearly identical, .43 and .42 respectively. Comparison of the long and short-term multipliers for these two exogenous variables suggests that price effects are passed through the system more gradually than other exogenous effects. This becomes even more evident as the long and short-term multipliers for such variables as income, population, and total-away-fromhome food sales are compared.

Figure 7.9 depicts forecasts for UZP which range in 1990 from 87.1 to 90.8 pounds per capita. These levels represent increases over 1981 predicted and actual levels of 16 to 21 percent. Much of this growth will stem from changes in income (IN), population (PN), fast food sales (FF) and women in the labor force (WN). Sizeable long-term multipliers are associated with each of these variables.

The long-term muliplier for IN shows that a sustained $1000 real per capita increase leads to future per capita increases in UZP of 6.8 pounds. An increase in PN of 1 million persons generates a long-term increase in UZP of .11 pounds. By comparison, a 1 percent permanent increase in WN leads to future increases in UZF of .17 pounds. At the

1980-81 growth rate of the labor force, a 1 percent increase in WN amounts to a net addition of 2.5 million women to the labor force. Fast-food sales has a long-term effect of a .17 pounds increase in UZP for a 1 percent increase. Translated into dollars, a 1 percent increase in FF at the 1980-81 growth rate amounts to roughly $1 million in real away from home food sales. In addition to these muliplier effects, the accuracy of these forecasts should be greatly enhanced by nearly identical 1981 predicted and actual values.

As seen in Figure 7.10, forecasts for the farm price of potatoes (FPR) are nearly identical under all growth scenarios. This lack of variation in the forecasts is due to the limited number of exogenous variables impacting FPR. Unlike some of the other endogenous variables which are greatly influenced by exogenous factors, FPR responds primarily to production. As shown in Figure 7.17, there is an inverse and highly correlated relationship between changes in QRP and FPR. With QRP being endogenous, forecasts for FPR are somewhat inaccurate.

Unlike FPR which is impacted by only three exogenous variables, WPP, depicted in Figure 7.11, is impacted by all exogenous variables. This serves not only to provide some differentials in the forecasts but also to enhance the accuracy of them. By 1990, WPP is forecasted to range from $5.09 to $5.40 per cwt. This represents a significant drop from the 1981 predicted and actual values of $6.52 and $6.71

respectively. Again it is emphasized that prices are deflated and therefore expressed as real prices.

The multipliers show that the long-term impact of a $1 per cwt increase in PS is a $1.03 increase in WPP. RPP, by contrast, increases $1.78 for each $1 increase in PS. This suggests that price increases at the wholesale level lead to even higher prices at the retail level. These multipliers, as compared to the impact multipliers, are indeed large. Impact multipliers for a $1 increase in PS are $.39 and $.67 increases in WPP and RPP respectively.

Given the erratic fluctuations in RPF depicted in Figure 7.12 together with the high correlation of RPF and QRP shown in Figure 7.18, it may be hypothesized that forecasts of RPF based solely on exogenous variables are likely to be somewhat inaccurate. That is, the reduced form for RPF, although good for predicting, performs poorly on forecasting. However, assuming smooth and only small changes in production over the forecast horizon, RPF may be expected to lie within the range of forecasts, particularly since the 1981 predicted and actual values are identical.

Unlike RPF which is poorly predicted by its reduced form, RPP is more satisfactorily predicted. Forecasts from the reduced form for RPP, however, are only marginally different for all scenarios. Suggested here is the fact that processed potato prices are expected to remain fairly stable irrespective of changes in exogenous factors. This stability is reflected in Figure 7.13.

Multipliers for RPP show that only PS has a substantial effect on processed prices. This effect was noted above. A 1 percent increase in dispersion of potato production (GD) leads to a long-term increase of $.04 increase in RPP. Assuming processing plants are located to minimize transportation cost, this suggests that production efficiencies decline as the number of plants increases. Alternatively, assuming a fixed number of plants, production efficiency may decline because of less efficient procurement practices associated with rising dispersion of production.

Forecasts for spread of retail and farm prices (SPR), depicted in Figure 7.14, are subject to the same limitations ascribed to RPF and FPR. In its structural form, SPR is estimated from a variable, marketing cost (MC), which shows little fluctuation; large fluctuations in SPR are therefore not explained. Forecasts from the reduced form of SPR approach a reasonable degree of accuracy only to the extent that fluctuations in SPR smooth out during the forecast horizon. Given the correlation of prices and production, and the dependency of production on weather, it is unlikely that fluctuations will not persist.

Another endogenous variable which is only marginally impacted by exogenous factors is RPT. As can be seen in Figure 7.15, forecasts from all growth scenarios yield nearly identical values. This lack of differentials in forecasts stems from relatively small multiplier effects for all exogenous variables. Indeed, in its structural form, RPT changes only in response to endogenous factors. Despite the lack of differentials among the forecasts, future RPT will probably approximate these changes in the absence of a change in the tax rate.

Lastly, as seen in Figure 7.16, forecasts for UZO are of questionable accuracy because of large period to period fluctuations and sizeable discrepanies between 1981 predicted and actual values. Additionally, since UZO is estimated in its structural form as the residual of total utilization, accurate forecasts for UZO depend on the extent to which UZF and UZP are accurately predicted.

In summary, most forecasts are believed to be characteristic of the changes which will evolve for the potato industry for the next decade. Endogenous variables which exhibited large fluctuations during the data period are likely to be less accurately forecasted. Forecasts for variables of great significance and interest to the potato industry, such as demand for fresh and processed potatoes, are believed to characterize the boundaries of change during the forecast horizon. The potato industry though can serve as a catalyst in accelerating the depicted rates of changes.

CHAPTER VIII
IMPLICATIONS OF MODEL

Introduction

As captured by the data span of this study, the potato industry during the past two decades has been in considerable transition. Although many factors have served to alter the structure of the industry, an issue of paramount concern to firms comprising the industry is the identification of those factors which most likely will continue to propel the industry forward. To this end, this chapter will discuss and depict the effects that selected exogenous variables are likely to have on growth of the potato industry.

The approach used in this chapter is a "what if" type of analysis. For example, what if fast-food expenditures maintain or exceed its most recent rates of growth? How will such changes impact, for example, consumption of fresh and processed potatoes? This policy evaluation type of analysis is known as policy simulation. Alternative policy evaluation approaches are discussed, but these are deemed inapplicable to this study.

Policy Evaluation

Three approaches to policy evaluation using estimated econometric models have been developed by economists. These approaches include (1) instruments-targets, (2) social-welfare function and (3) simulation (Klein, 1971; Intriligator, 1978; Naylor, 1971). All of these approaches have been used at various times to evaluate policy alternatives. The present study, however, is limited to simulation because, as discussed below, use of the first two approaches requires information not readily available with the models as estimated.

The instruments-targets approach to policy evaluation was developed by Tinbergen (1956) and it appears to be most useful in an economic development planning context (Intriligator, 1978). Essentially the approach requires the setting of specific targets for each endogenous variable and then determining instruments (exogenous policy variables) to accomplish the targets. In essence, typical econometric estimating procedures are reversed as endogenous variables are fixed and values for instruments are obtained from the solution (Klein, 1971).

The instruments-targets approach is inapplicable to the present study because neither specific targets nor preferable instruments are hypothesized. Moreover, it is unlikely that firms comprising the potato industry could delineate targets and instruments. Intriligator (1978) contends that even if firms or policymakers could delineate targets, there are likely to be tradeoffs among them that are not allowed for with this approach. Additionally, delineated targets are not achievable unless the number of available instruments equals or exceeds the number of targets. These limitations make this approach both inapplicable and impractical for the present study.

The social welfare function is an alternative policy evaluation approach which relaxes the setting of targets for endogenous variables, but adds an elusive and abstract welfare function (Naylor, 1971). Using the aforementioned nomenclature, this approach involves the determination of targets and instruments which will maximize a specified welfare function subject to constraints imposed by the econometric model. Intriligator (1978) contends that policymakers not only cannot identify the parameters of a welfare function, but cannot identify even its functional form. Such limitations obviously make this approach infeasible for the present study.

The only economic policy evaluation approach which utilizes an estimated econometric model is that of simulation. This approach is quite useful and appropriate for this study because it requires the researcher to neither ascertain nor elicit apriori information from policymakers. In fact, simulation may be used to show policymakers the consequences of policies which are being considered for enactment. That is, it provides policymakers with the type of information which they are most likely to require in order to make decisions (Naylor, 1971).

As alluded to earlier, policy variables in the present study are not typical policy variables in that they cannot be easily manipulated or controlled. Fast-food expenditures, for example, cannot be influenced by firms comprising the potato industry as readily as say the Federal Reserve can influence the market rate of interest. The potato industry, however, has an unrelenting interest in the impact of changes in fast-food expenditures since potatoes comprise a large percentage of these expenditures. Thus, these simulations are of interest to policymakers associated with the potato industry in that consequences of changes in selected variables are evaluated and depicted. It should be emphasized that some of the policy variables discussed here, such as advertising and size of plant, are indeed controlled by policymakers; others, such as fast food expenditures and non-fast-food expenditures, can be greatly influenced by them.

As used in this study, policy simulation refers to the determination of values of the endogenous variables for alternatively assumed sets of values of the policy variables (Intriligator, 1978). That is, behavior of a system is determined as values of endogenous variables are calculated from an estimated model of the system (Intriligator, 1978). The estimated model for these simulations is that shown in equation 7.2 and reproduced below as equation 8.1.

$$(8.1) \quad Y_t = X_t \beta + U_t$$

In estimating this equation, all exogenous variables except the one being simulated are held at their actual values for

1981, the last year of the data span. To better reflect the impacts of policy variables on the potato industry, it may be noted that lagged endogenous variables are also held to their 1981 values. Allowing the system to determine initial lagged values and then using their values in future estimates is tantamount to measuring effects from more than one factor.

Eight policy variables are simulated and their effects on eight endogenous variables are evaluated and depicted. Each variable is simulated through 1990, but values are normalized to one with 1981 serving as the base. This normalization allows for a comparison of effects among endogenous variables as it negates scale effects. Three levels of simulations are performed: each variable is simulated at (1) its 1976-8 mean rate of change; (2) a 3 percent rate of change; and (3) a 6 percent rate of change. The mean change of most policy variables, as shown in Table 8.1, is less than 3 percent. Larger effects on the endogenous variables should therefore be realized as policy simulations progress from mean changes to 6 percent changes.

Policy Simulation Results

Summary measures of the impacts of each policy variable on all endogenous variables are provided in Tables 8.1, 8.2 and 8.3. Results in Table 8.1 reflect the mean changes and should be read down the columns whereas those in Tables 8.2 and 8.3 can be read down the columns and across the rows. As an example, the second column of Table 8.1 delineates the

Table 8.1--Simulation Results: Impact of Policy Variables on Selected Endogenous Variables (1990 Values of Endogenous Variables Relative to Their 1981 Value of 1.0)

Endogenous Variable	Policy Variable and Its Mean Rate of Change								Policy variable with greatest impact on endogenous variable
	ASRL	FF	NF	WN	PN	IN	MS	CT	
	2.5	4.6	1.1	1.6	1.1	.1	6.1	8.3	
NPP	.9982	.9987	.9999	.9989	.9987	.9999	.8286	.4227	CT
CRP	1.0086	1.0004	1.0000	1.0004	1.0004	1.0000	1.0243	1.0417	CT
PCM	.9844	.9983	.9999	.9966	.9983	.9998	.9498	.8980	CT
ASR	1.0106	1.0091	1.0002	1.0078	1.0089	1.0007	1.0103	1.0186	CT
UZF	.9954	.9438	.9980	.9469	.9482	.9967	.9862	.9719	FF
UZP	1.0383	1.0290	1.0005	1.0236	1.0291	1.0024	1.0127	1.0254	ASRL
WPP	.9907	.9989	.9999	.9991	.9989	.9999	.9700	.9391	CT
RPP	.9898	.9999	.9999	.9990	.9987	.9999	.9672	.9333	CT

NF is the nonfast food component of TF.

Table 8.2--Simulation Results: Impact of 3 Percent Changes in Policy Variables on Selected Endogenous Variables (1990 Values of Endogenous Variables Relative to Their 1981 Value of 1.0)

Endogenous variable	Policy Variable								Policy variable with greatest impact on endogenous variable
	ASRL	FF	NF	WN	PN	IN	MS	CT	
NPP	.9978	.9991	.9998	.9979	.9963	.9968	.9143	.7916	CT
CRP	1.0103	1.0003	1.0000	1.0007	1.0012	1.0009	1.0121	1.0151	CT
PCM	.9812	.9988	.9998	.9972	.9951	.9959	.9749	.9632	CT
ASR	1.0128	1.0061	1.0009	1.0151	1.0254	1.0203	1.0051	1.0067	PN
UZF	.9945	.9623	.9926	.8973	.8521	.9003	.9931	.9898	PN
UZP	1.0461	1.0195	1.0024	1.0456	1.0831	1.0709	1.0064	1.0092	PN
WPP	.9888	.9993	.9989	.9983	.9971	.9976	.9850	.9781	CT
RPP	.9877	.9993	.9999	.9982	.9968	.9973	.9836	.9759	CT

NF is the nonfast food component of TF.

Table 8.3--Simulation Results: Impact of 6 Percent Changes in Policy Variables on Selected Endogenous Variables (1990 Values of Endogenous Variables Relative to Their 1981 Value of 1.0)

Endogenous Variable	Policy Variable								Policy Variable with greatest impact on endogenous variable
	ASRL	FF	NF	WN	PN	IN	MS	CT	
NPP	.9956	.9983	.9997	.9958	.9925	.9936	.8286	.5832	CT
CRP	1.0207	1.0006	1.0001	1.0014	1.0025	1.0019	1.0243	1.0301	CT
PCM	.9624	.9978	.9995	.9944	.9901	.9918	.9498	.9264	CT
ASR	1.0255	1.0117	1.0026	1.0302	1.0508	1.0405	1.0103	1.0134	PN
UZF	.9889	.9281	.9801	.7946	.7041	.8007	.9862	.9797	PN
UZP	1.0922	1.0371	1.0075	1.0912	1.1661	1.1418	1.0127	1.0183	PN
WPP	.9775	.9987	.9997	.9966	.9941	.9951	.9700	.9560	CT
RPP	.9754	.9985	.9977	.9964	.9935	.9946	.9672	.9518	CT

NF is the nonfast food component of TF.

impacts of a 2.5 percent increase (the mean value) in advertising on specified endogenous variables, whereas the third column shows the effects of a 4.6 percent increase in fast-food expenditures on these same variables. All policy variables shown in Table 8.2 change at a 3 percent rate whereas those in Table 8.3 change at a 6 percent rate. These identical changes make comparisons meaningful both down the columns and across the rows. Note that all other variable values can be ignored since these effects are cancelled out with the indexing to 1981.

While summaries of policy simulations are provided in the tables, growth paths of several endogenous variables emanating from changes of policy variables also are depicted in the figures. Both the endogenous and policy variables reflected in each figure are carefully labeled to facilitate an understanding of them. Each endogenous variable is depicted on the vertical axis while each policy variable is shown on the horizontal axis.

Assuming a continuation of the mean changes of policy variables as shown in Table 8.1, it follows that transportation cost (CT) will have the greatest impact on all endogenous variables except consumption of fresh (UZF) and processed (UZP) potatoes. This, of course, should have been expected given the sizeable mean change in CT relative to the other policy variables. However, when all policy variables are simulated at comparable rates, 3 percent and 6 percent, CT continues to have the largest impact on the aforementioned endogenous variables, save advertising sales ratio (ASR). With respect to ASR, population (PN) has the dominant effect and it also has the dominant effect on fresh and processed potatoes. Policy simulations on mean changes in Table 8.1 show that fast-food expenditures (FF) and lagged advertising sales ratio (ASRL) have the dominant effects on fresh and processed potatoes respectively.

While CT has the largest relative impact on several endogenous variables, its most dramatic effect is on NPP. Given the observed changes in transportation cost since 1981, the 3 percent changes reflected in Table 8.2 and Figure 8.1 should most closely characterize the future rate of change of CT and therefore its resulting impact on NPP. The future effect on NPP from MS is best characterized by those shown in Tables 8.1 or 8.3 and depicted in Figure 8.2.

In Table 8.1 the mean change of potato advertising is 2.5 percent. Advertising expenditures on potatoes subsequent to the data span would suggest increases in this mean. As an example, through increased advertising, processors of frozen potatoes have diminished the pool of non-consuming households of frozen potatoes from 50 percent in 1977 to 40 percent in 1981, a decline of 20 percent (Corddry, 1977; Kluth, 1981). Projecting this increasing trend into the future, those changes reflected in Table 8.2 and Figure 8.3 are likely to characterize the future effects of advertising on processed potatoes.

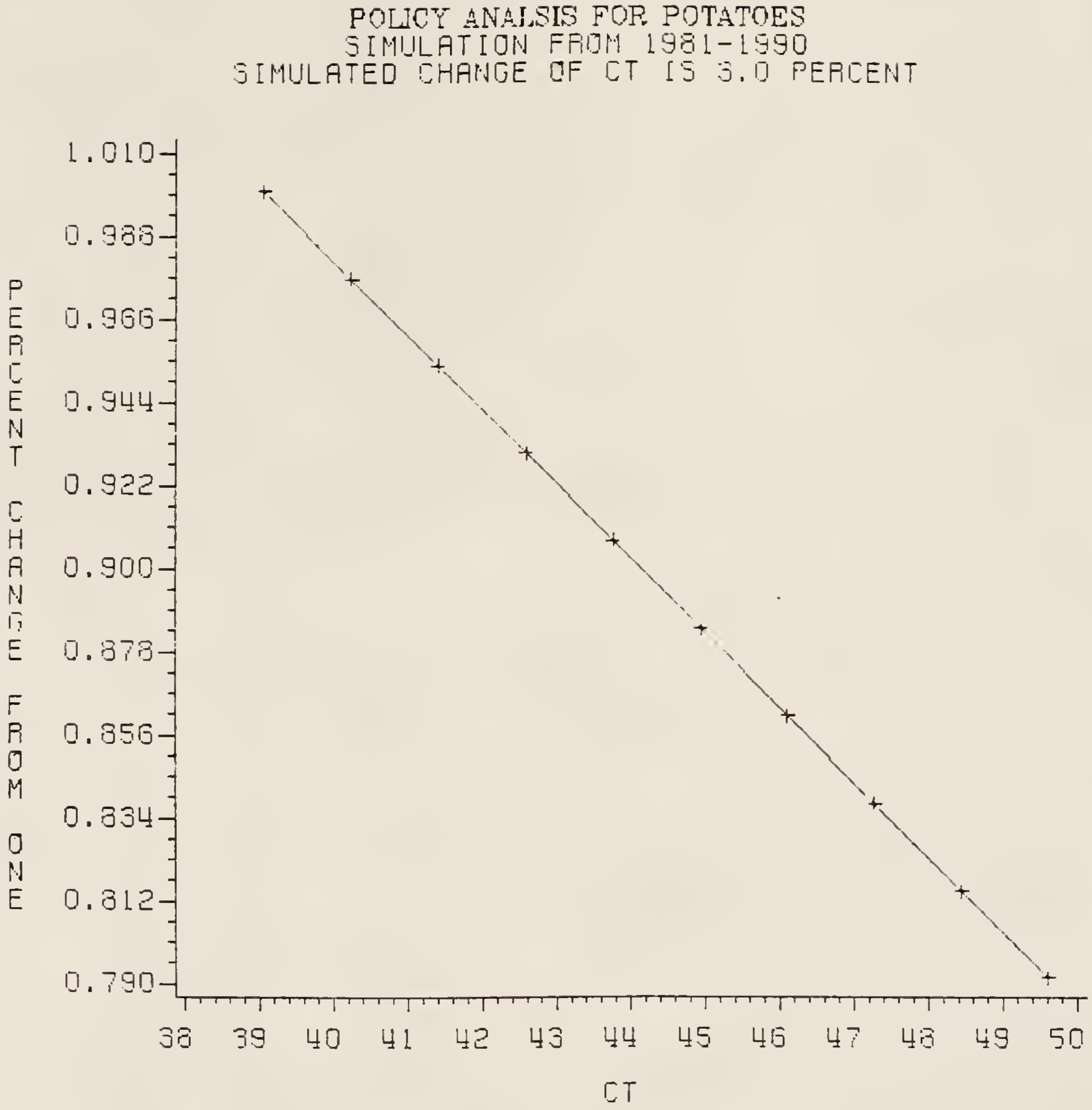


Figure 8.1. Simulated Effect of Transportation Cost on Potato Processing Plants

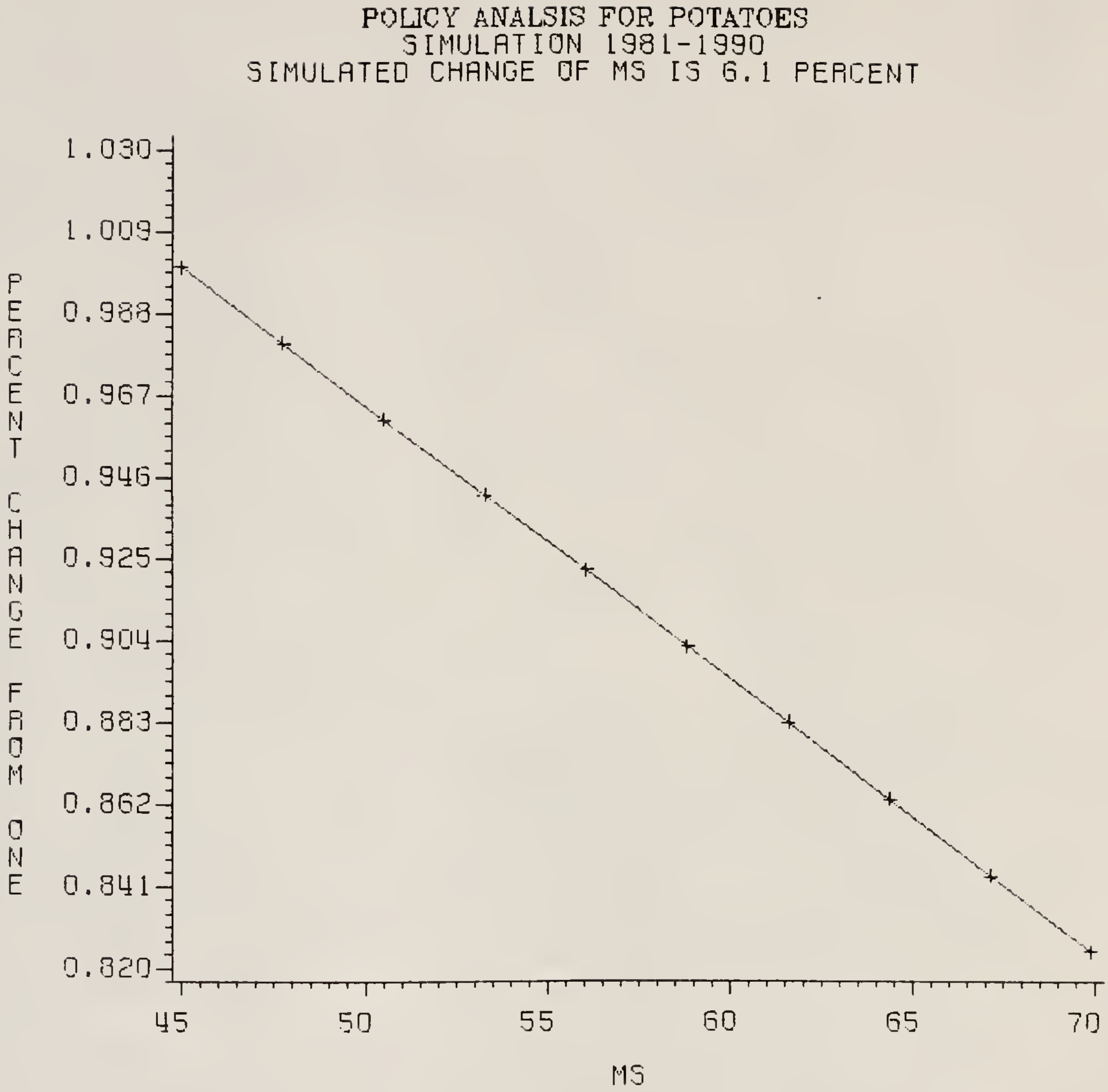


Figure 8.2. Simulated Effect of Minimum Efficient Plant Size on Potato Processing Plants

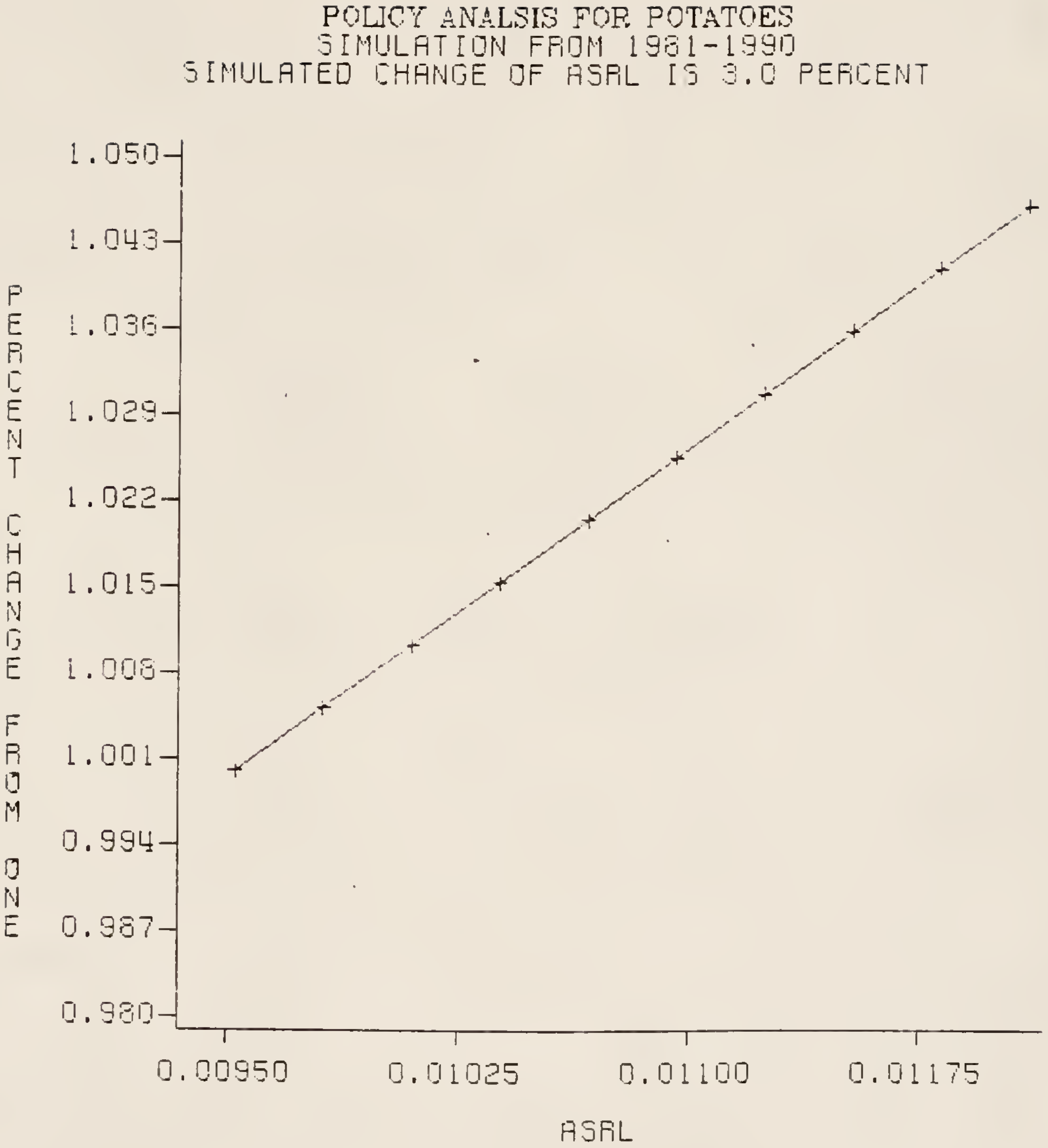


Figure 8.3. Simulated Effect of Advertising Sales Ratio on Consumption of Processed Potatoes

Although advertising of processed potatoes has a tremendous demand-enhancing impact on consumption of processed potatoes, it has only a small demand-reducing impact on consumption of fresh potatoes. ASRL has its second largest impact on price-cost-margins (PCM). The time path of change in PCM emanating from a 2.5 percent change in ASRL is depicted in Figure 8.4. Although not depicted in figures, Tables 8.1--8.3 show that ASRL also has price-reducing impacts on wholesale (WPP) and retail (RPP) prices of processed potatoes, though the impacts are less than those on PCM.

While total-food expenditures (TF) and fast-food expenditures (FF) are included in the structural form of the model, an intriguing phenomenon is revealed in separate simulation of fast food and non-fast food (NF). That is, the components of TF are isolated to measure their separate effects. Revealed immediately from this isolation is a 4.6 percent mean change in FF for the 1976-81 period as compared to a 1.1 percent mean change in NF. Jointly, these components change at a mean rate of 2.1 percent. Simulation on the mean changes of FF and NF, shown in Table 8.1, reveals that FF has a significant demand-reducing effect on UZF and a sizeable demand-enhancing effect on UZP; by comparison, NF has only small demand-reducing and demand-enhancing effects respectively on UZF and UZP. The paths of change for UZF and UZP emanating from a mean change of FF are depicted respectively in Figures 8.5 and 8.6.

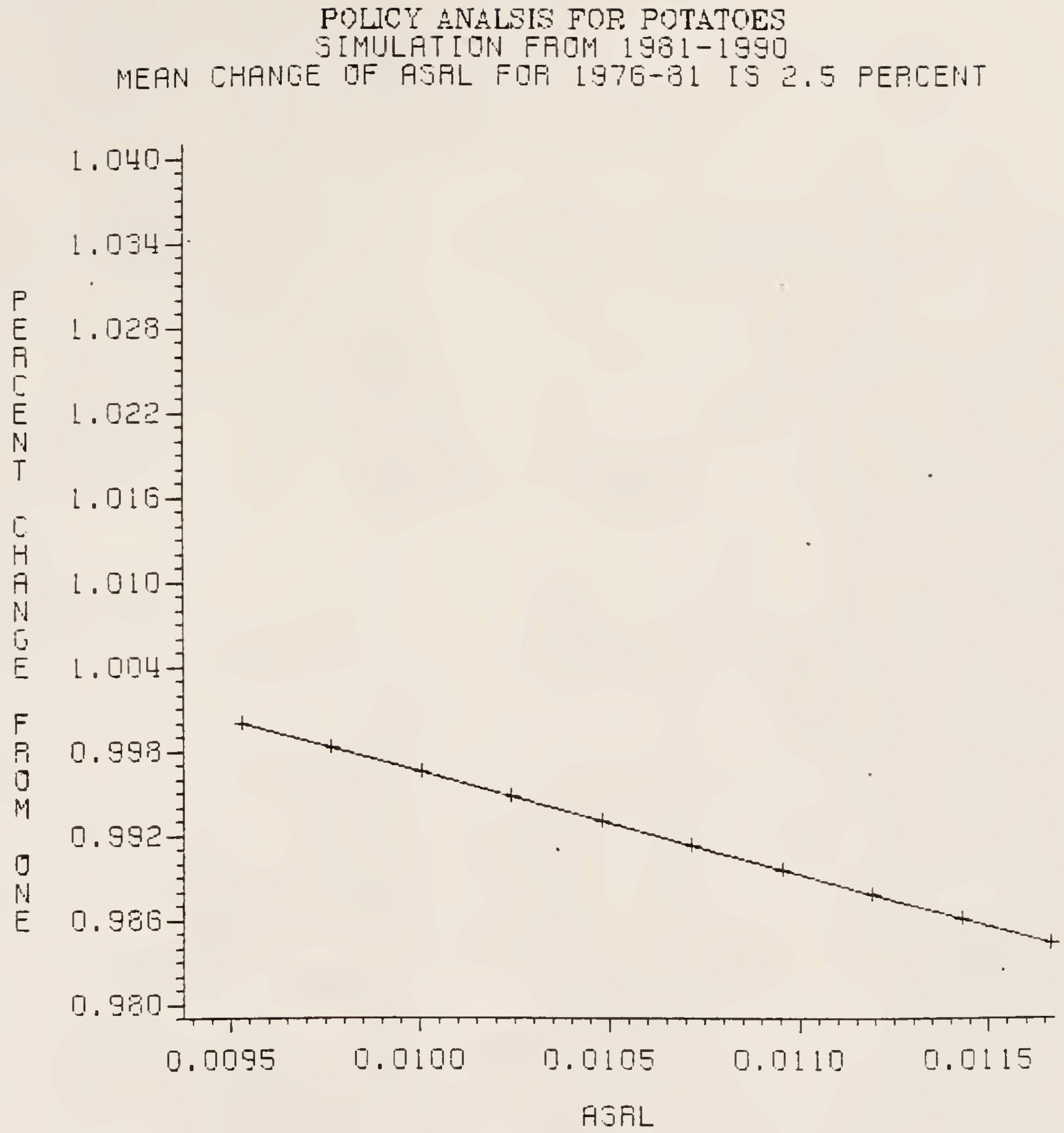


Figure 8.4. Simulated Effect of Advertising Sales Ratio
on Price Cost Margins

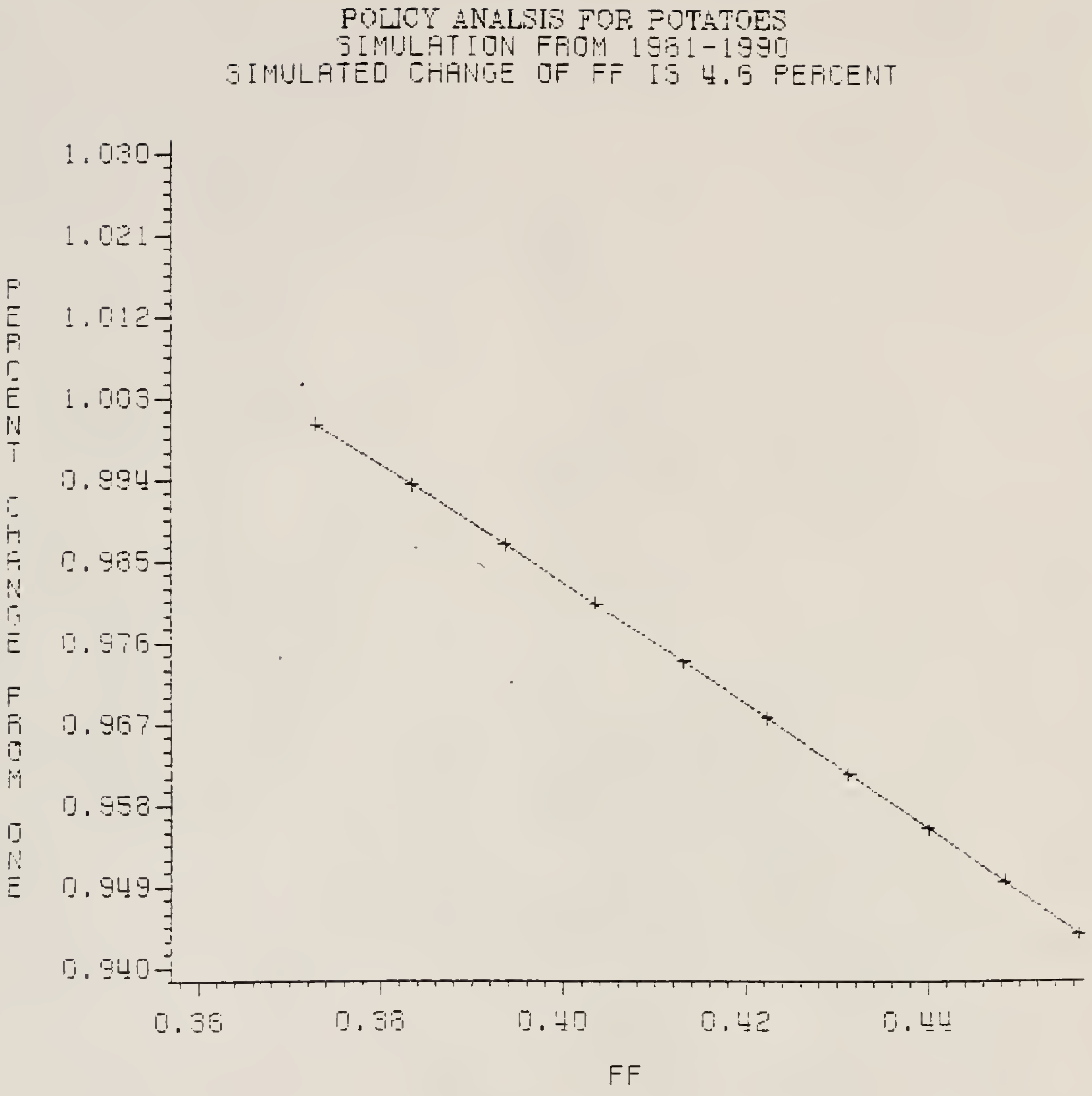


Figure 8.5. Simulated Effect of Fast Food Consumption on Consumption of Fresh Potatoes

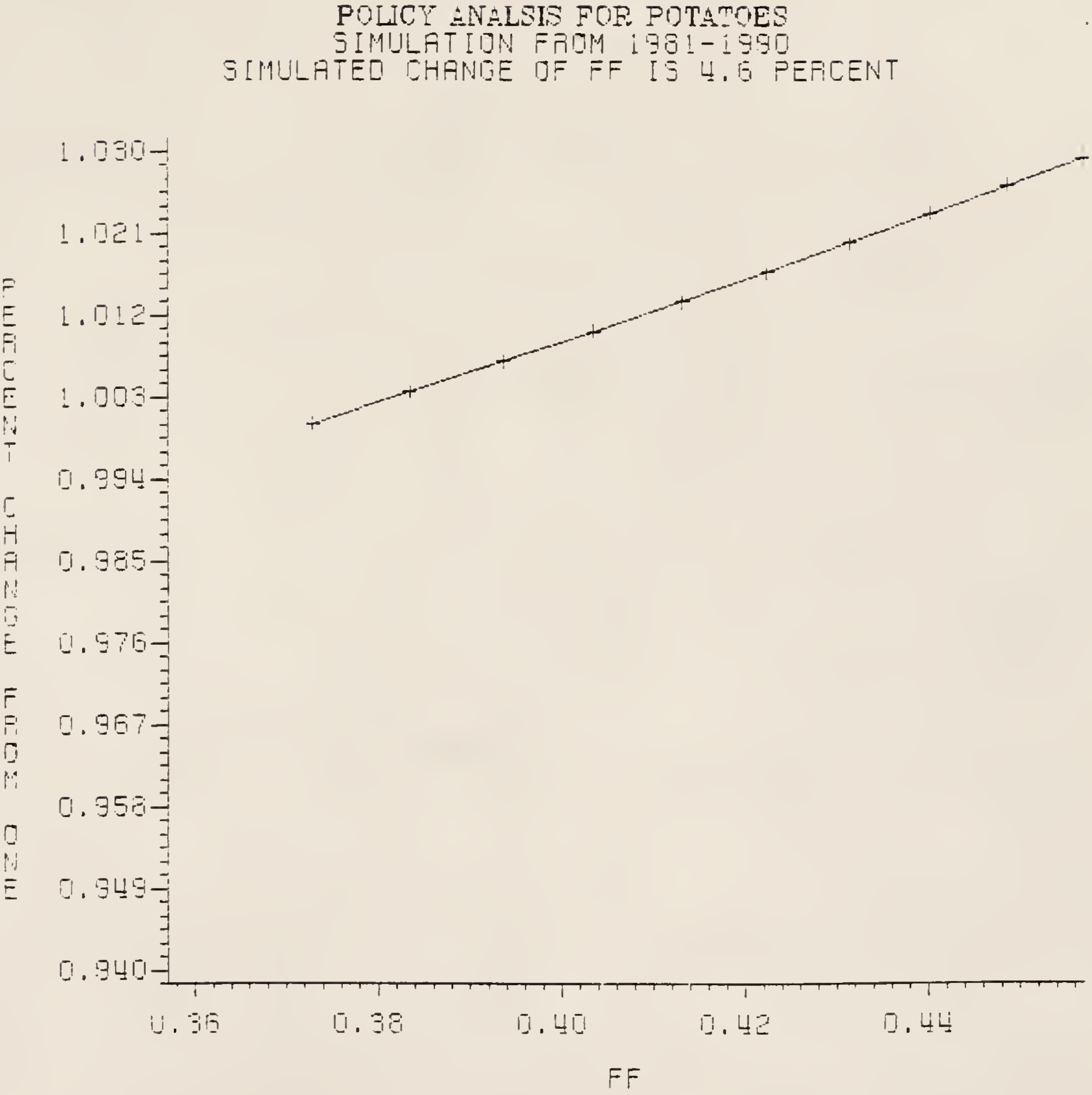


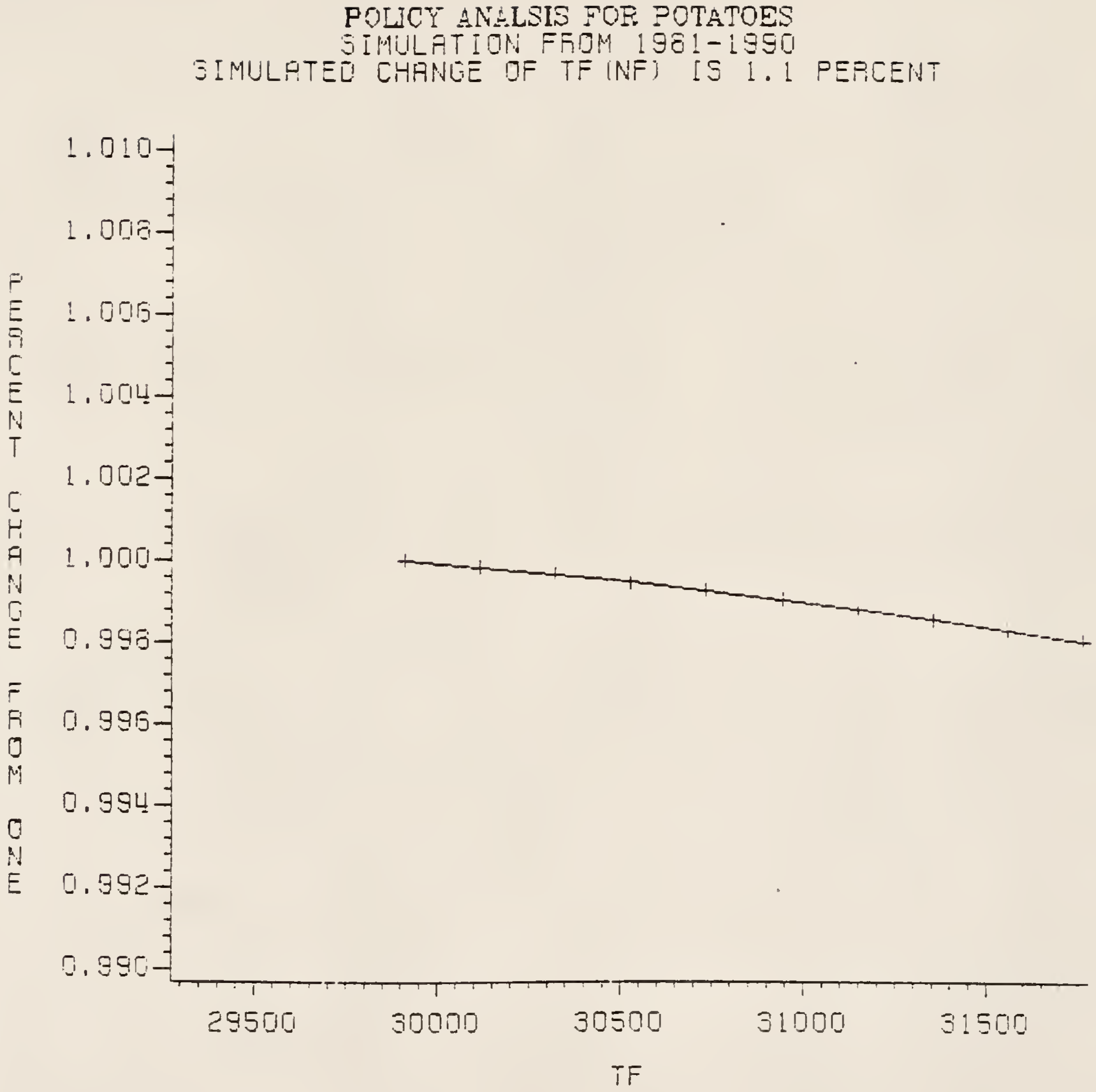
Figure 8.6. Simulated Effect of Fast Food Consumption on Consumption of Processed Potatoes

Similarly, Figures 8.7 and 8.8 show the paths of change for UZF and UZP respectively which emerge from a mean change of non fast-food (NF).

While all figures are plotted against an index to facilitate comparisons among variables, the underlying changes reflected in the index of the last four mentioned figures are discussed subsequently. Implicit in Figure 8.5 is the fact that a continual 4.6 percent change in FF will lead after nine years to a 2.6 pounds reduction in per capita consumption of fresh potatoes. Per capita consumption of processed potatoes, as reflected in Figure 8.6, will increase by 2.2 pounds after nine years of a 4.6 percent change in FF. By contrast, a 1.1 percent increase in NF will lead to a reduction in per capita consumption of UZF by only .09 pounds, and only a .03 pounds increase in per capita consumption of UZP. These changes, shown in Table C.9, are also interable from Figures 8.7 and 8.8.

While food expenditures at fast food outlets have significant impacts on UZF and UZP, their effects on other endogenous variables are only minimal by comparisons. These relative effects may have been expected as, unlike UZF and UZP, other endogenous variables are only indirectly impacted by fast food expenditures.

Growth of women in the labor force (WN) has effects on the endogenous variables similar to those of fast food expenditures. That is, as compared to UZF and UZP, other endogenous variables are only marginally impacted by WN.



POLICY ANALSIS FOR POTATOES
SIMULATION FROM 1981-1990
SIMULATED CHANGE OF TF (NF) IS 1.1 PERCENT

Figure 8.7. Simulated Effect of Non-Fast Food Consumption on Consumption of Fresh Potatoes

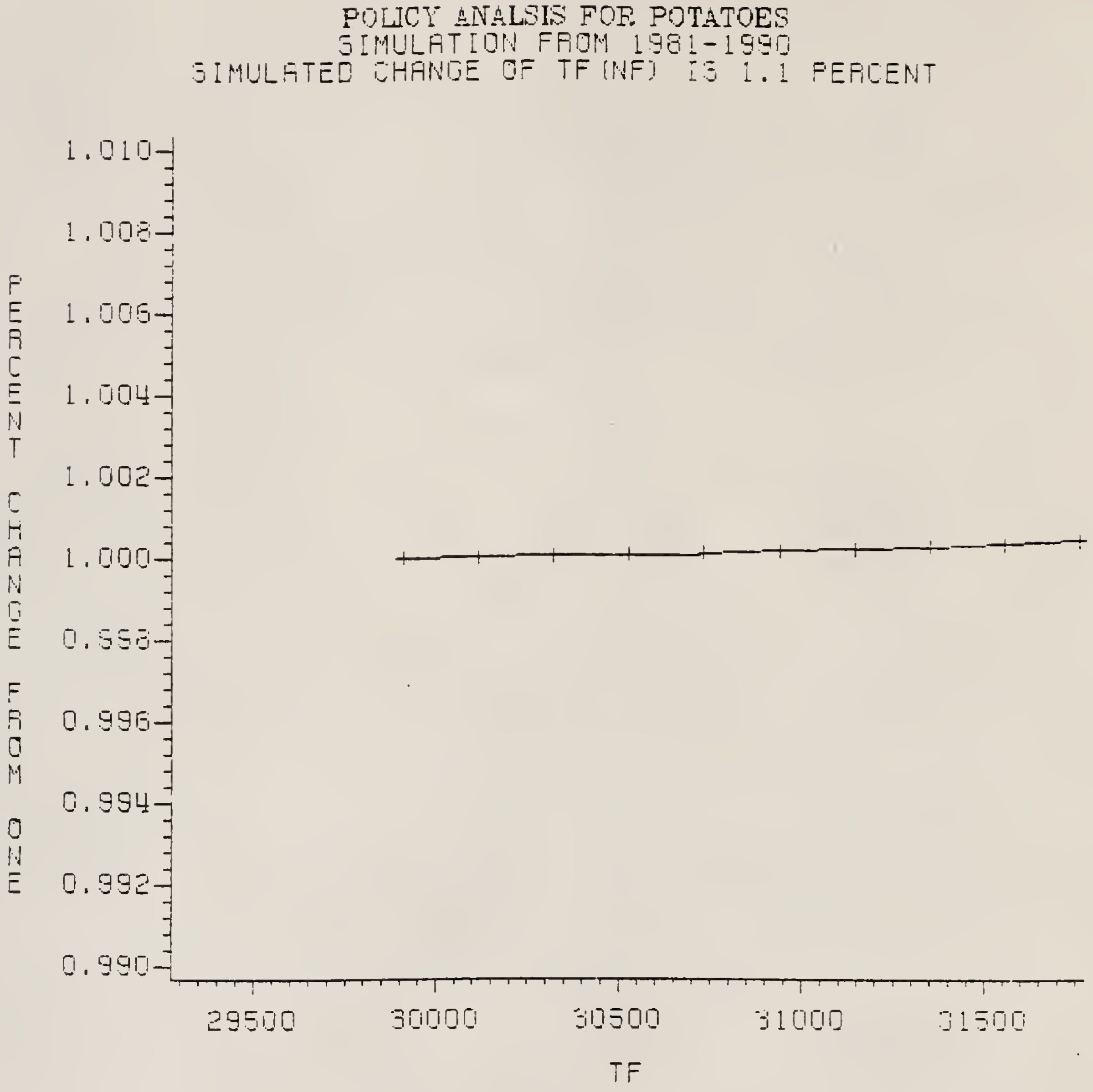


Figure 8.8. Simulated Effect of Non-Fast Food Food Consumption on Consumption of Processed Potatoes

Table 8.1 shows that a continual 1.6 percent mean change of WN leads to a sizeable reduction in UZF and a significant increase in UZP. Translated into per capita consumption of potatoes, UZF after nine years falls by 2.5 pounds per capita while UZP increases by 1.8 pounds per capita. A 3 percent increase in WN over a nine year period, however, causes a 4.8 pound per capita decline in UZF and a 3.4 pound per capita increase in UZP. These described changes are depicted in Table C.9 and Figures 8.9 and 8.10.

Though the mean change of population (PN) is only 1.1 percent, Table 8.1 reveals that a continuation of this change would have a significant demand-reducing effect on UZF and a sizeable demand-enhancing effect on UZP. An increase of 3 percent in PN, shown in Table 8.2, would further depress the demand for UZF but enhance the demand for UZP. Because prevailing socio-economic conditions probably would suggest future changes in PN which more closely approximate its mean rate of change, Figures 8.11 and 8.12 depict changes emerging from this mean. As with preceding policy variables, PN has marginal effects on other endogenous variables as compared to that on UZF and UZP. Revealed from Table 8.2, however, is the fact that, of all demand shifters, PN has the greatest effect on ASR.

As shown in Table 8.1, the mean change of real per capita income (IN) for 1976-81 is only .1 percent. Projecting this change into the future yields impacts on UZF and UZP which are as inconsequential as those of non-fast

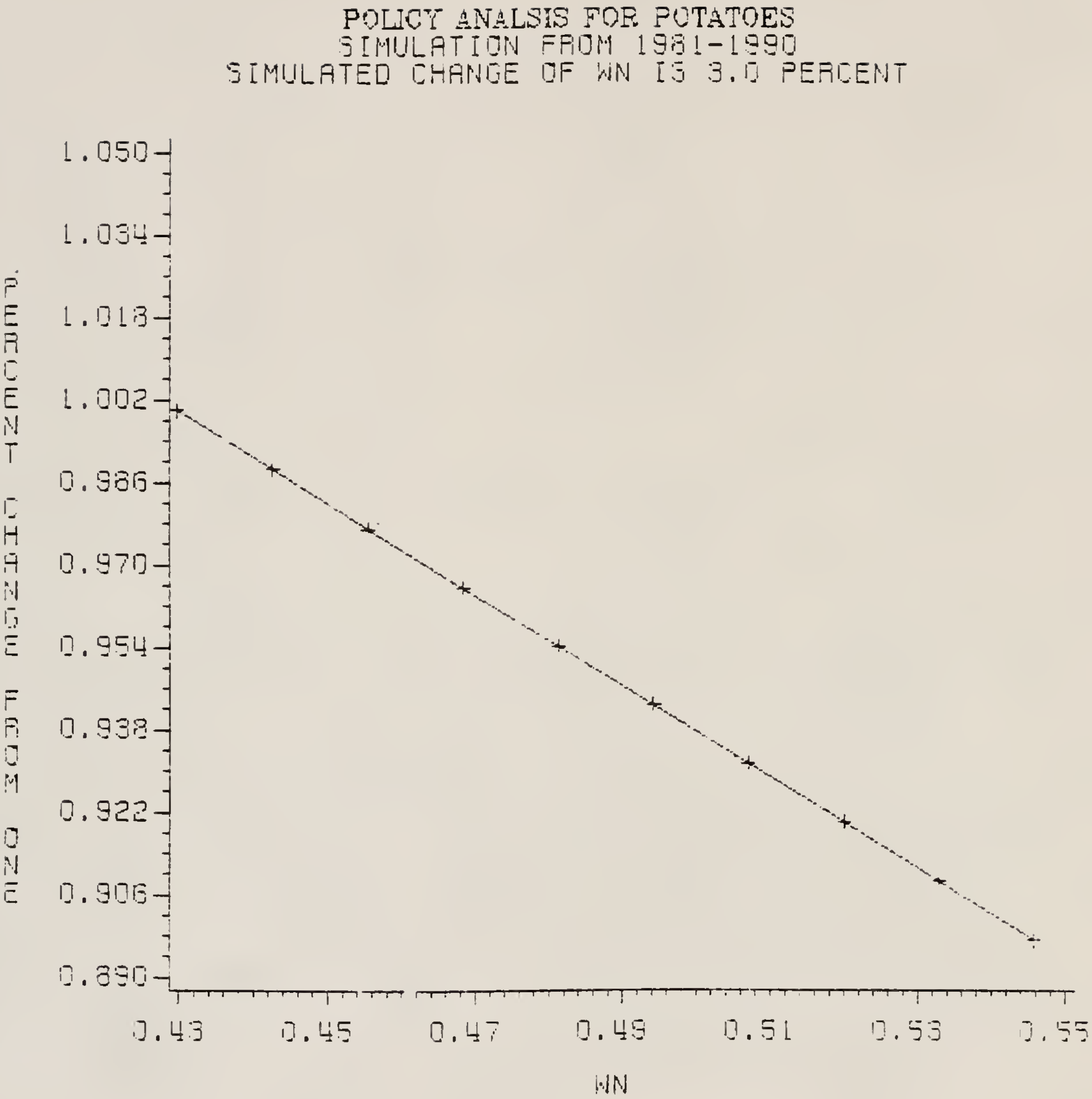


Figure 8.9. Simulated Effect of Women in the Labor Force on Consumption of Fresh Potatoes

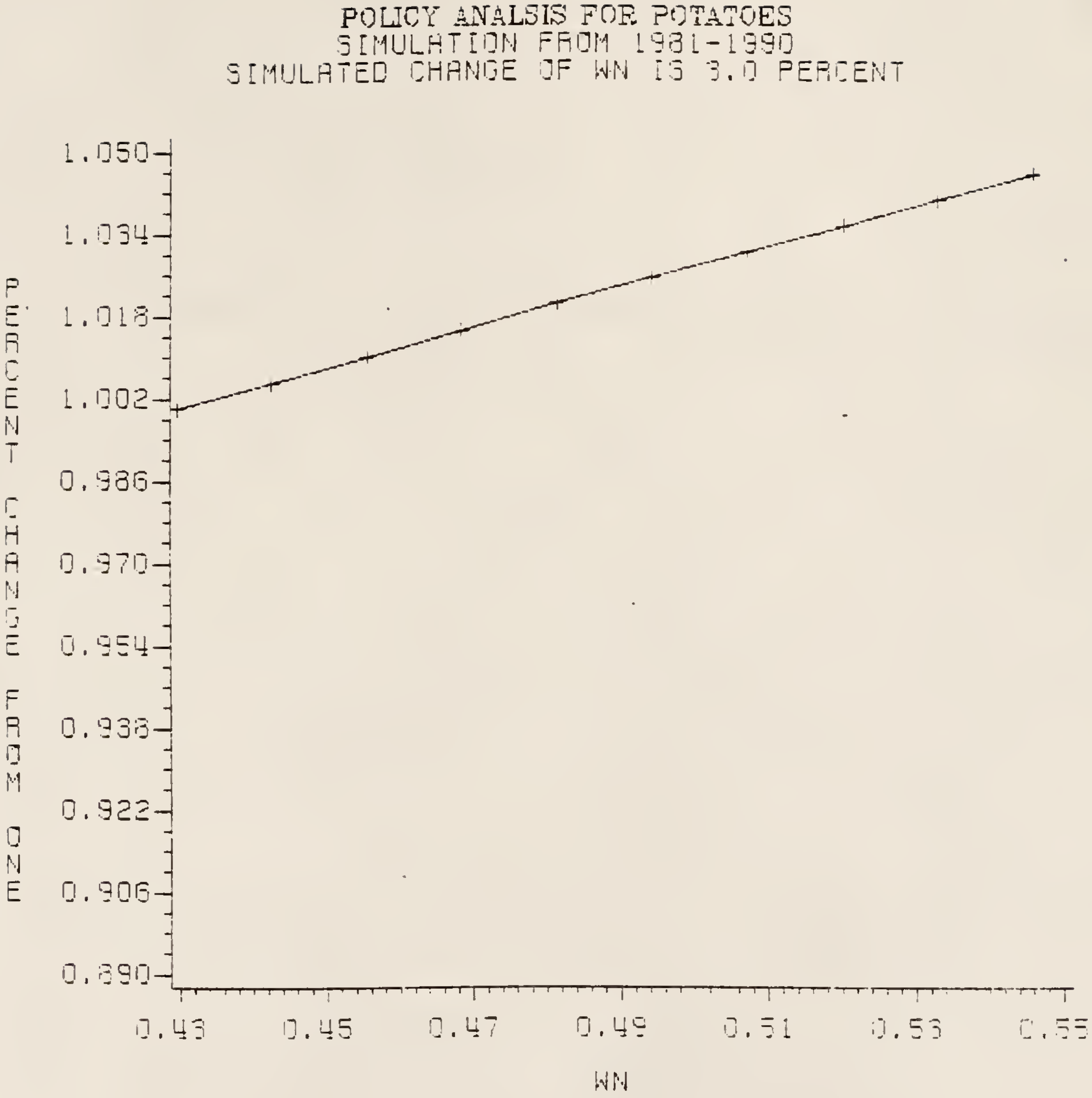


Figure 8.10. Simulated Effect of Women in the Labor Force on Consumption of Processed Potatoes

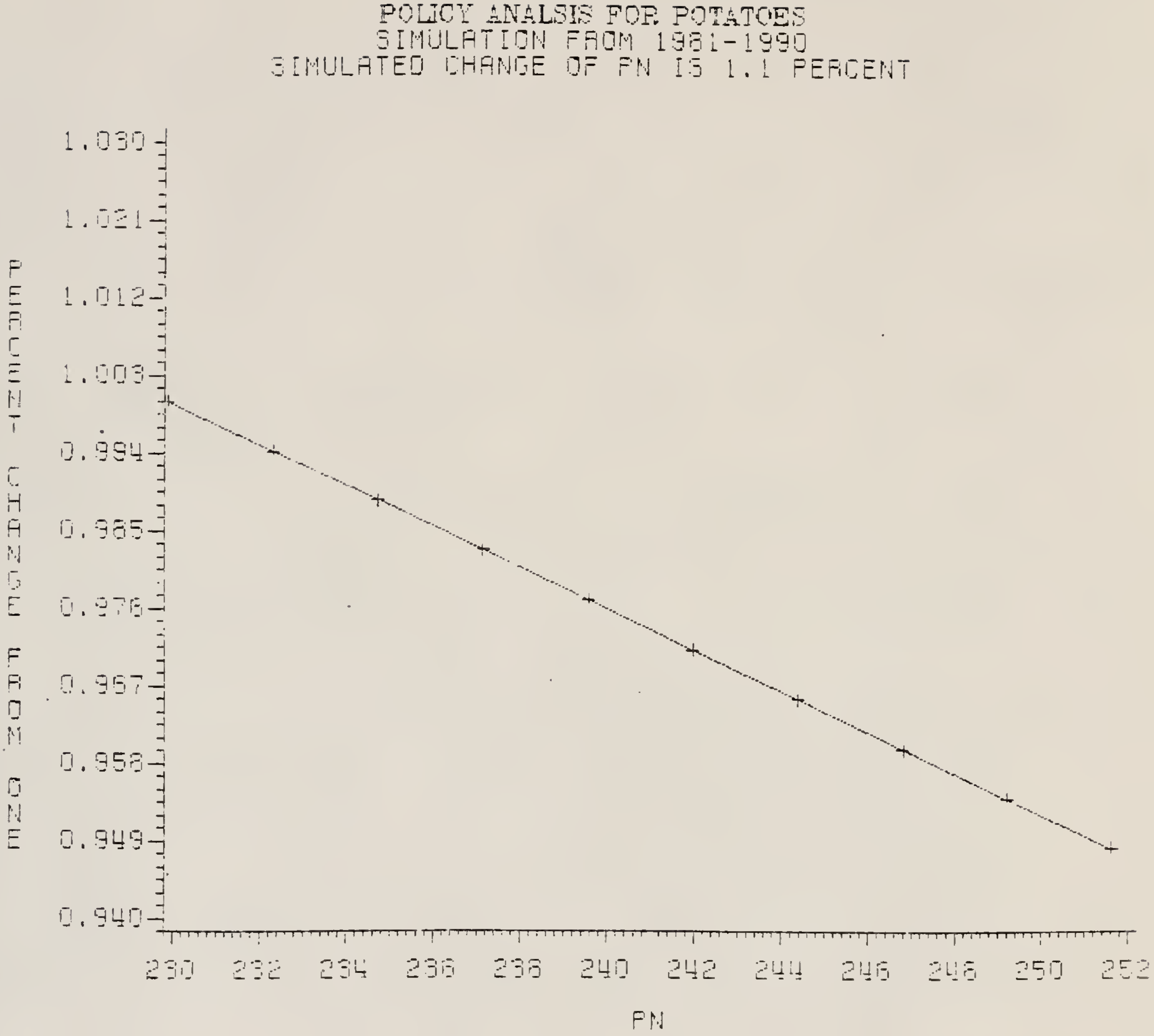


Figure 8.11. Simulated Effect of Population on Consumption of Fresh Potatoes

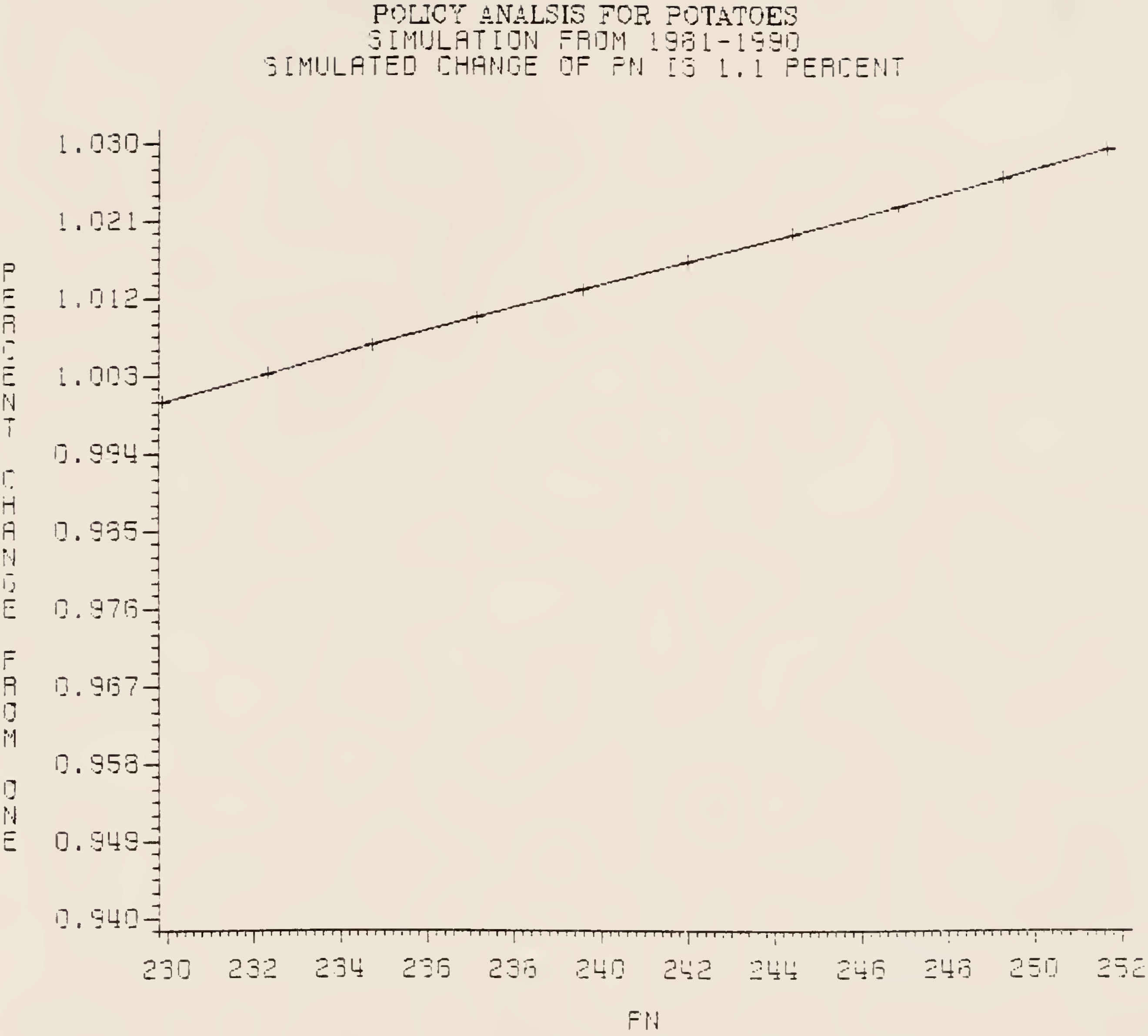


Figure 8.12. Simulated Effect of Population on Consumption of Processed Potatoes

food expenditures. A 3 percent increase in IN, however, has an adverse and large impact on UZF, but a positive and significant impact on UZP. As a 3 percent real growth of IN is probable, Figures 8.13 and 8.14 depict the growth paths of UZF and UZP which stem from this change. In per capita consumption figures, UZF would decline over a nine year period by 4.7 pounds while UZP would increase by 5.3 pounds. The comparative effects of IN on other endogenous variables relative to those on UZF and UZP are negligible.

A continuation of the mean change in minimum efficient plant size (MS), shown in Table 8.1, would lead to a significant loss in NPP and sizeable reductions in PCM, RPP, WPP and UZF. By contrast, large to moderate increases would be realized in CRP, UZP, and ASR. In actual numbers, plant losses after nine years would total 34 while UZF would decline by .65 pounds. Concentration and UZP, on the other hand, would increase respectively by 1.7 percent and .95 pounds. Changes in the aforementioned price and advertising variables, while small in absolute numbers, are significant relative to their base. The growth paths of change in the endogenous variables resulting from MS are depicted in Figures 8.2 and 8.15 through 8.21.

A point worth emphasizing here is the inverse impacts of MS on NPP and ASR. Implicit here is the fact that as NPP declines, there is a loss of smaller firms and a gain of market shares by larger firms. These larger firms, with a higher propensity to advertise together with a larger pool

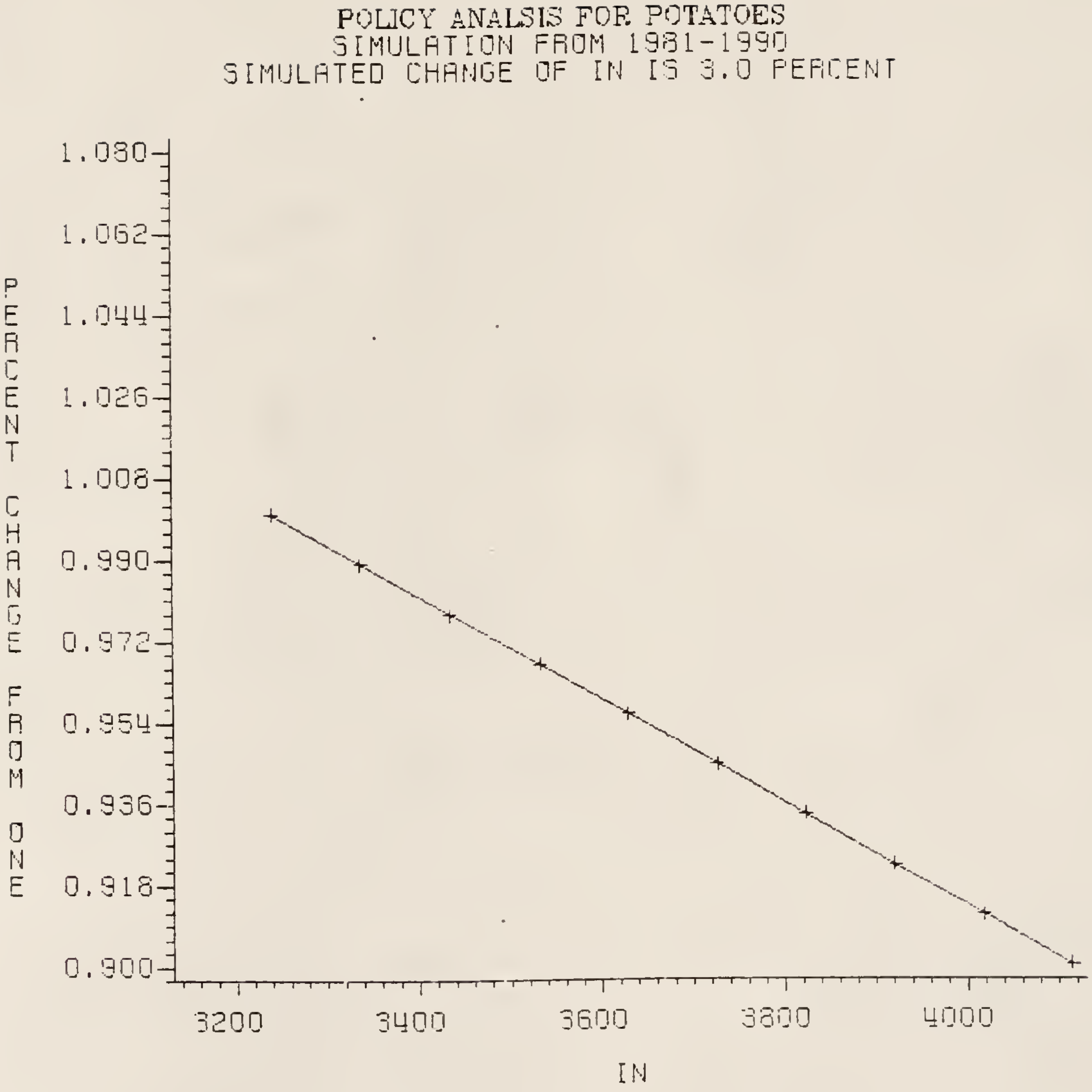


Figure 8.13. Simulated Effect of Income on Consumption of Fresh Potatoes

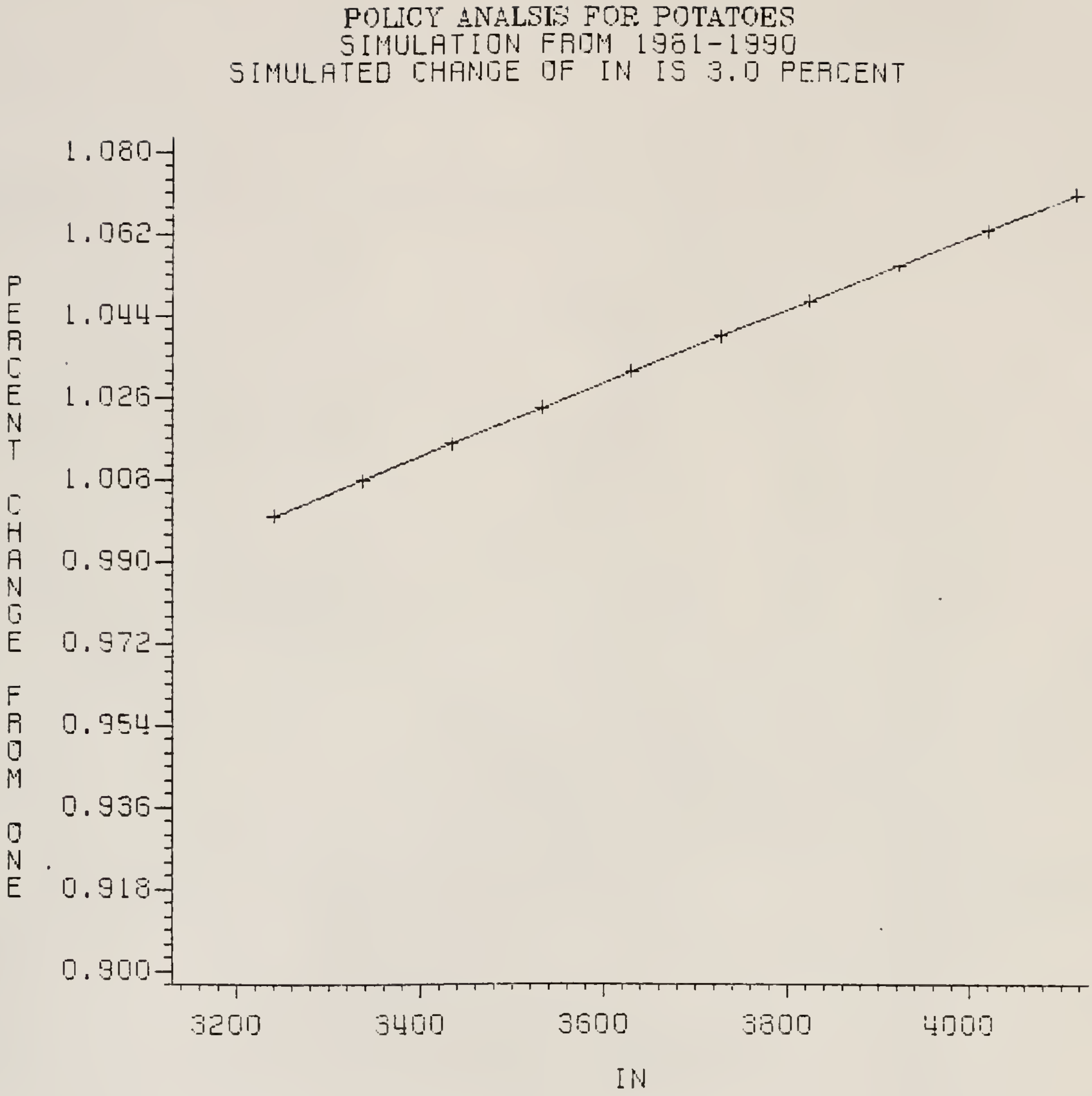


Figure 8.14. Simulated Effect of Income on Consumption of Processed Potatoes

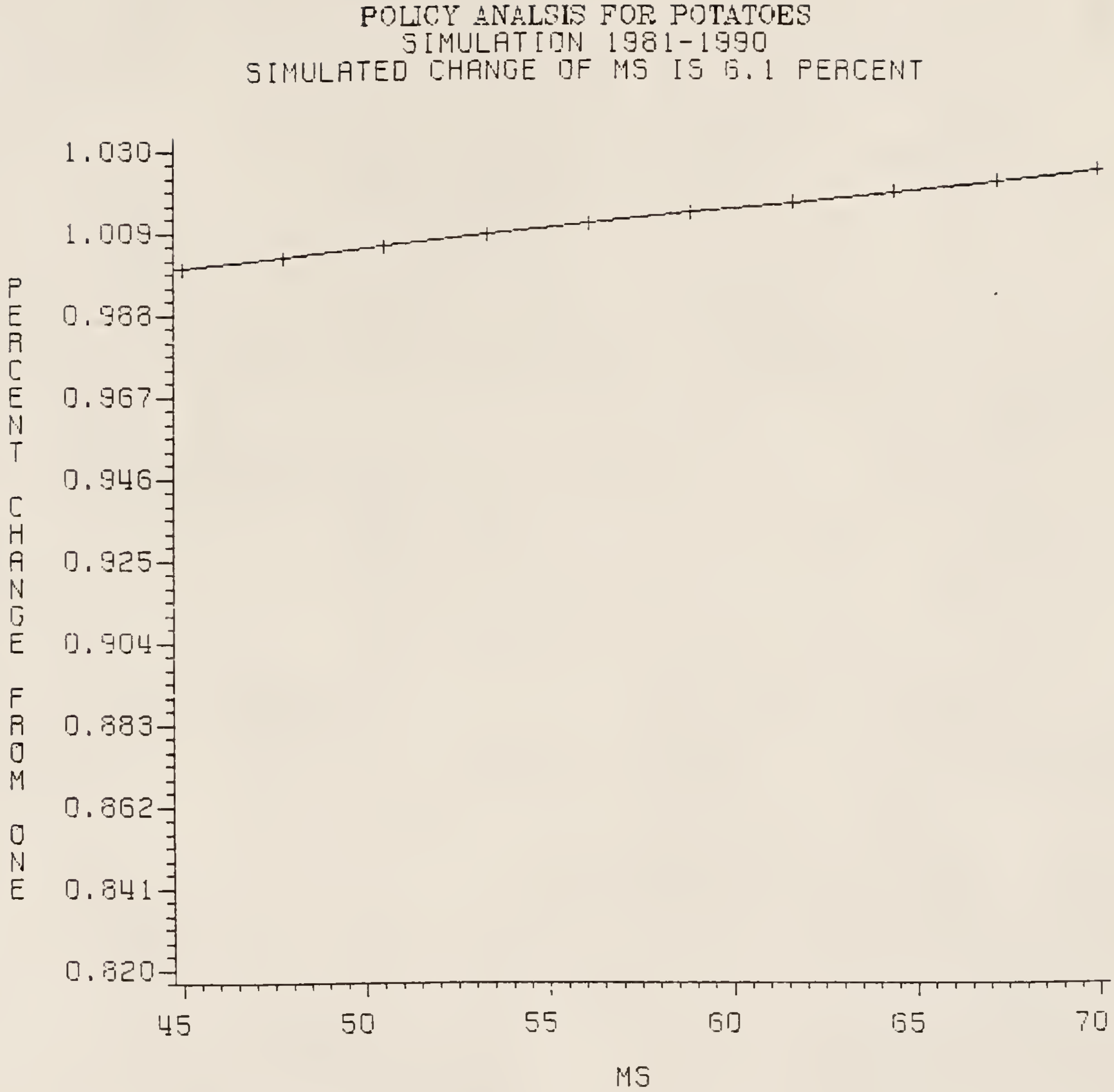


Figure 8.15. Simulated Effect of Minimum Efficient Plant Size on Concentration

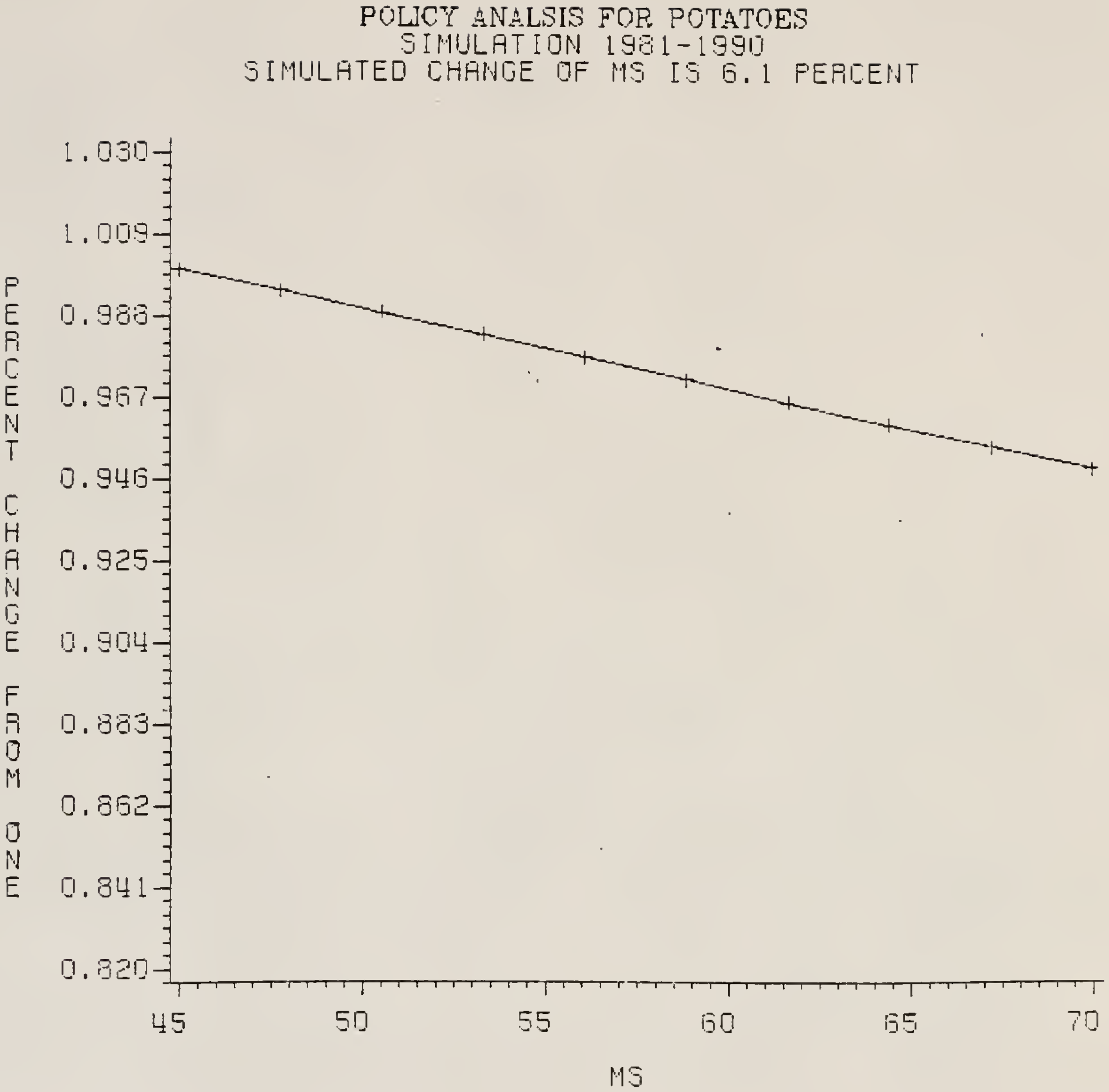


Figure 8.16. Simulated Effect of Minimum Efficient Plant Size on Price Cost Margins

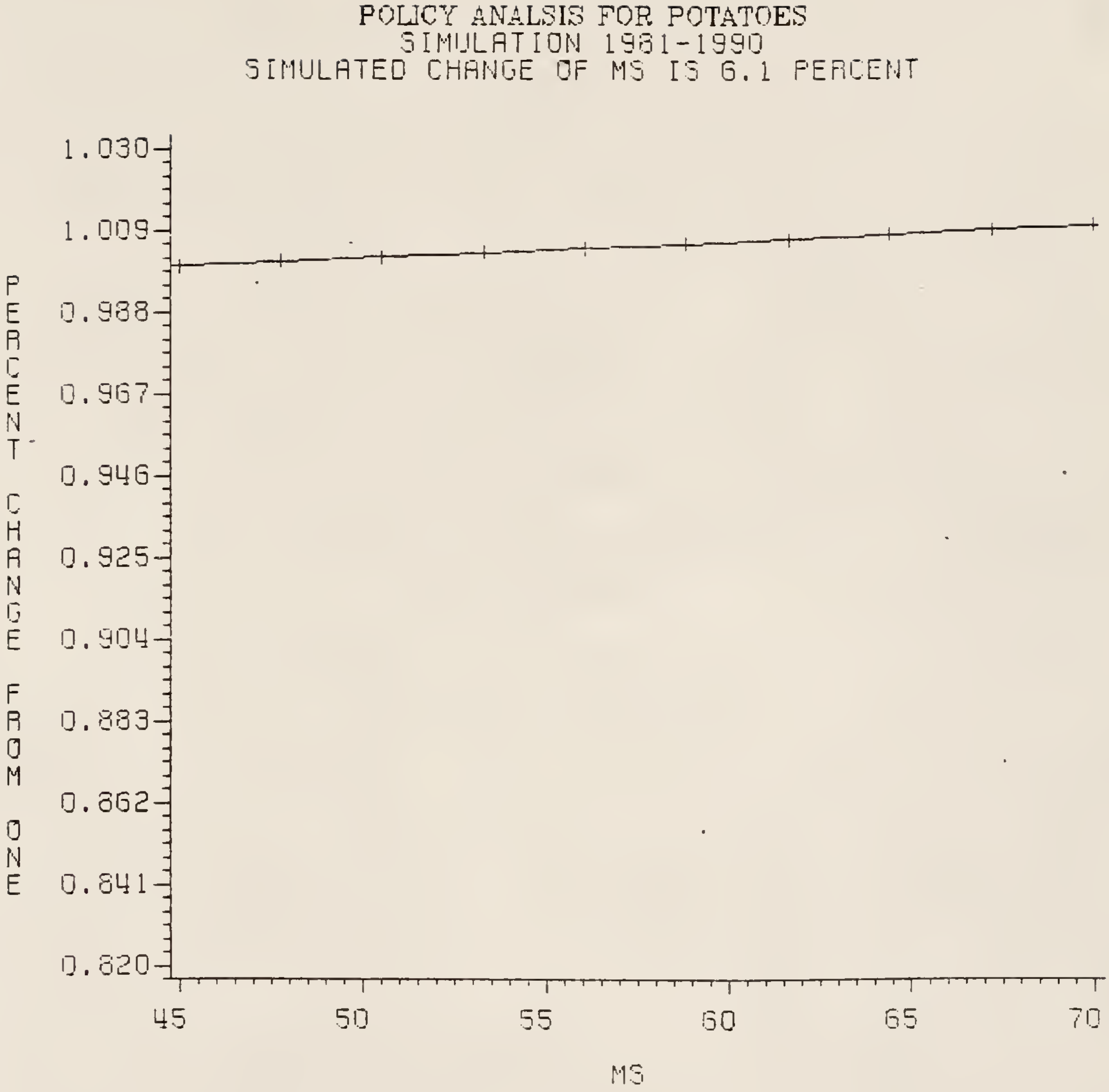


Figure 8.17. Simulated Effect of Minimum Efficient Plant Size on Advertising Sales Ratio

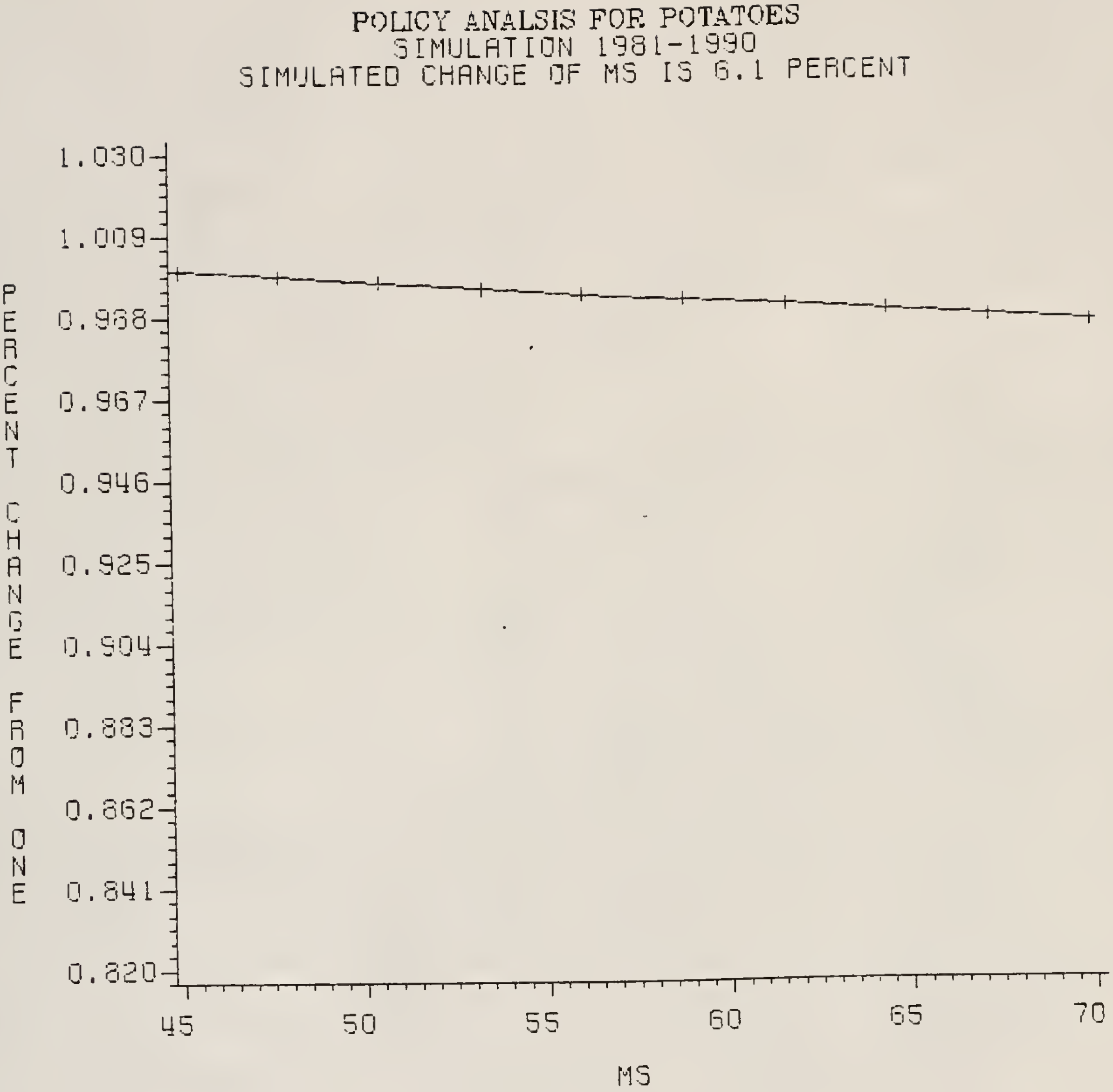


Figure 8.18. Simulated Effect of Minimum Efficient Plant Size on Consumption of Fresh Potatoes

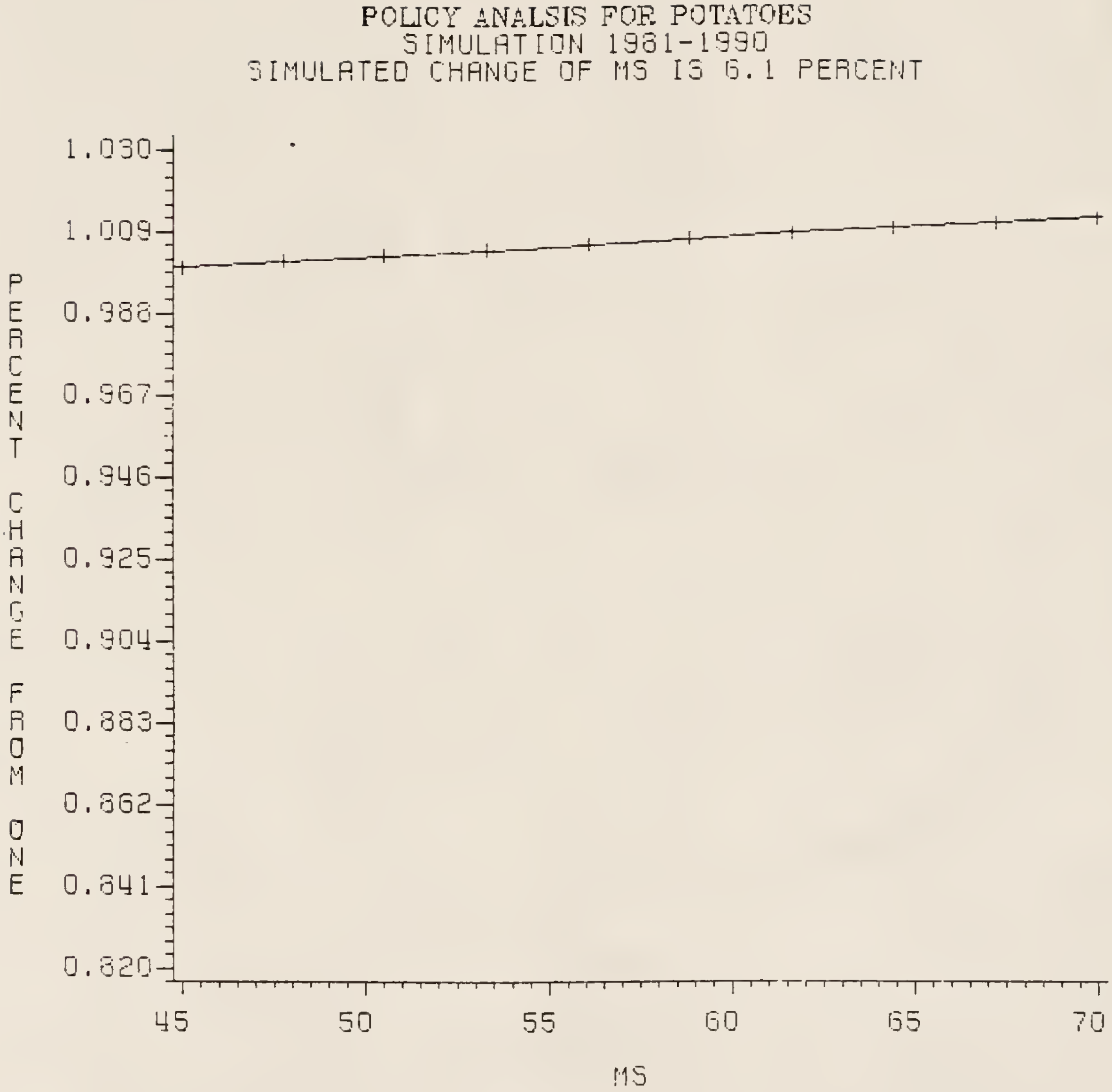


Figure 8.19. Simulated Effect of Minimum Efficient Plant Size on Consumption of Processed Potatoes

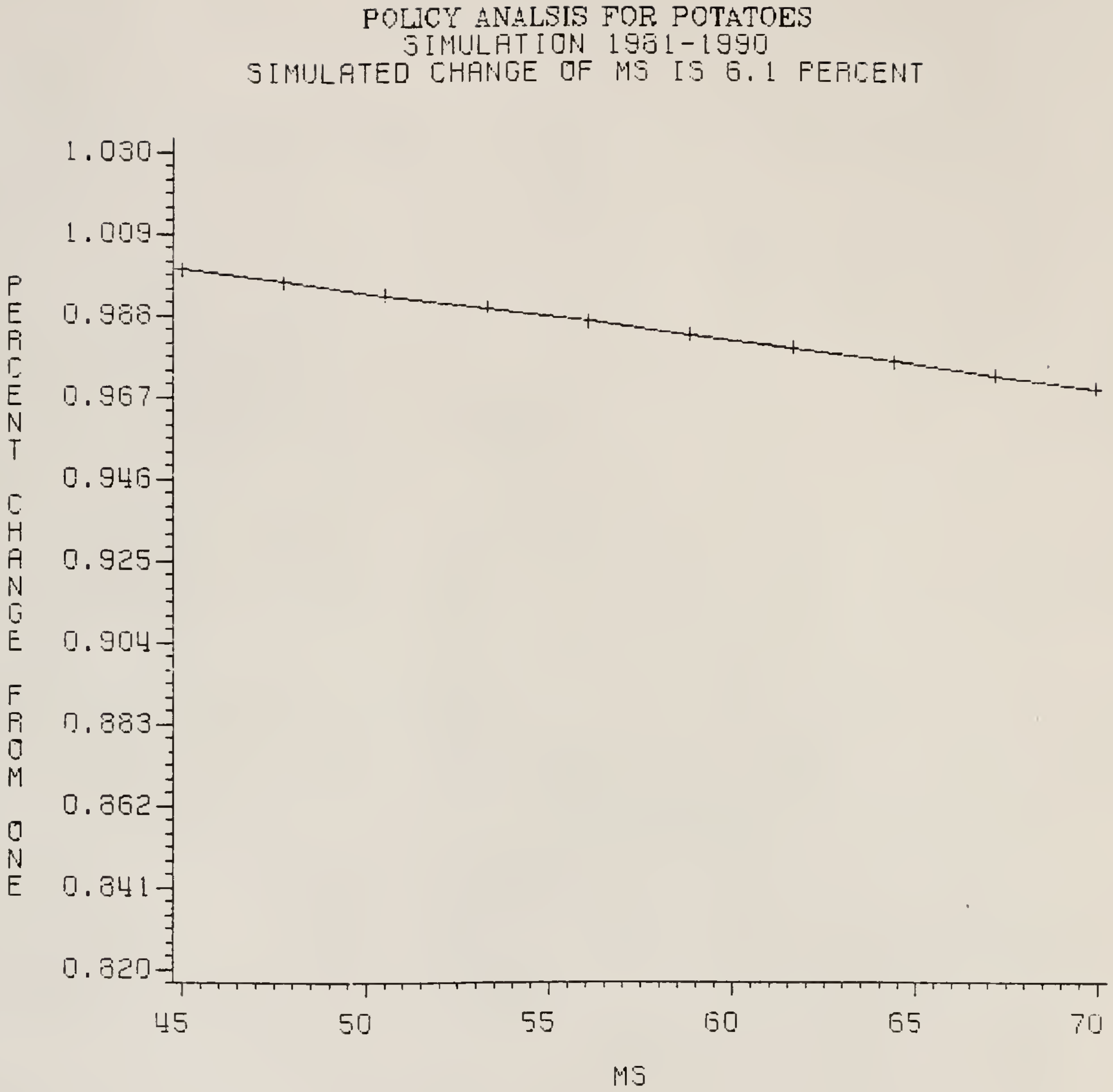


Figure 8.20. Simulated Effect of Minimum Efficient Plant Size on Wholesale Price of Processed Potatoes

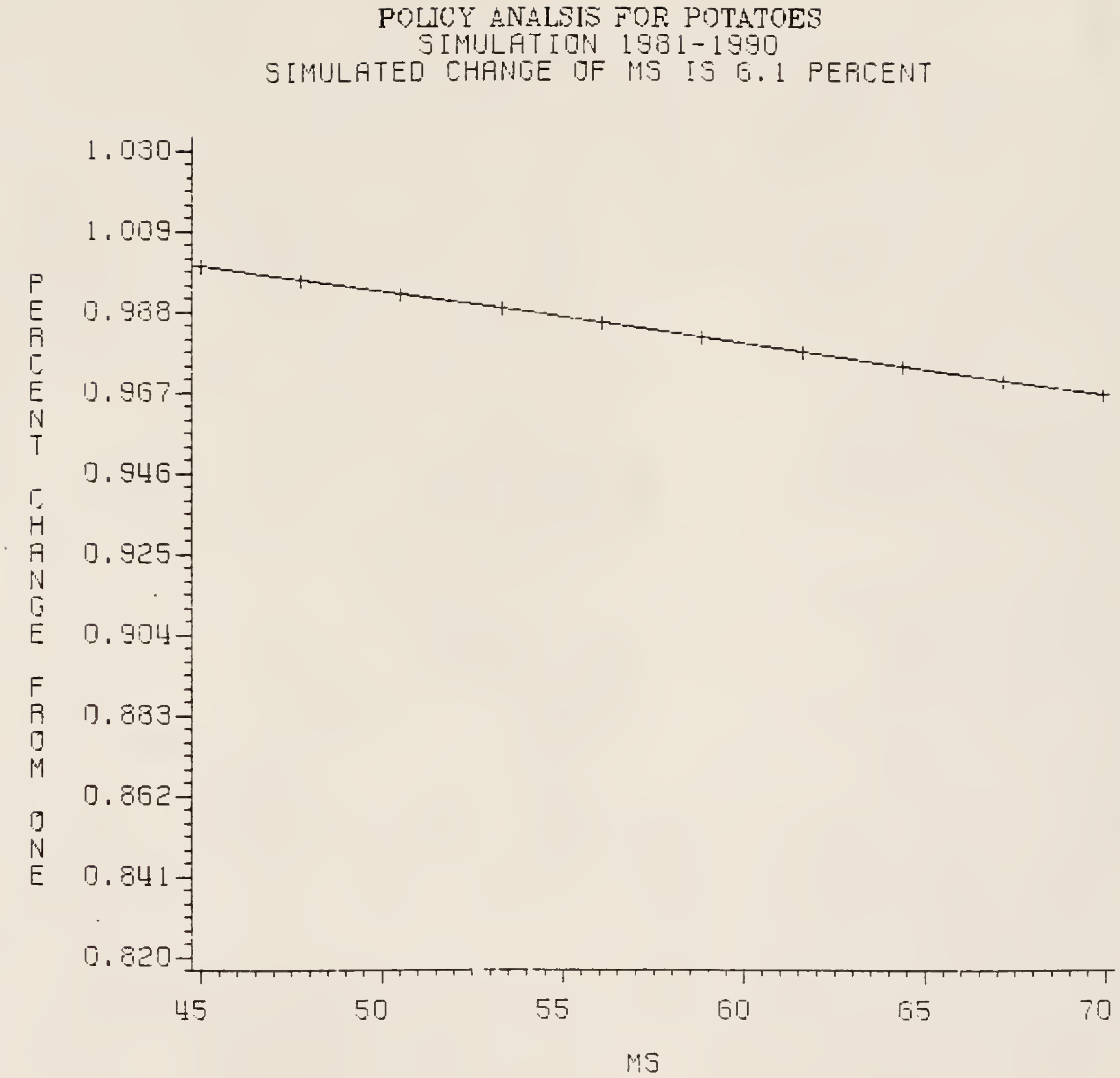


Figure 8.21. Simulated Effect of Minimum Efficient Plant Size on Retail Price of Processed Potatoes

of available resources, are therefore more prone to increase advertising and thereby further enhance the level of firm concentration. In addition, increased advertising, as previously seen, serves to enhance demand for processed potatoes.

While simulation of the mean change of MS leads to sizeable changes in several endogenous variables, Table 8.2 shows that a 3 percent change in MS leads to greatly reduced changes in these endogenous variables. The relevant question, of course, is which rate best characterize future changes in MS? And while this is not known, it should be emphasized that firms comprising the potato industry have significant control over this policy variable. Given the level of technological advancement in U.S. industries, an accelerated change in MS would seem more probable than a decelerated change. Thus, the described changes in Table 8.1 probably better characterize the future effects of MS on the endogenous variables.

To recapitulate, simulation on the mean of several policy variables seems to be an appropriate characterization of future rates of change. However, future changes in other policy variables seem to be either underestimated or overestimated by their mean rates. Since future changes in policy variables are known only within probability limits, provided here are the impacts on the endogenous variables from different rates of change of policy variables. Figures are provided which depict the growth paths of several endogenous variables. Depicted growth paths invariably emanate from that rate of change of policy variable which is perceived to represent the highest probability of future change. In other words, if a 3 percent rate of change is more likely to prevail than a 6 percent rate, the accompanying figures depict the 3 percent rate.

Conclusion

Policymakers, especially firms comprising the potato industry, can use the simulated results along with their informed opinions to make rational policy decisions. Although future changes in the policy variables may not correspond to the three simulated rates, as a minimum, future changes most likely will fall within the range of those simulated.

Of particular significance to firms comprising the potato industry are the impacts their actions alone--through increased advertising and plant size, for example--can have on the industry. Other variables such as fast-food and non-fast food sales can be greatly influenced by these firms, especially the potato components of these sales. Results from the simulations obviously would suggest a concentration of firms' effort on the fastfood market over the non-fast food market. These results also seem to suggest that fresh potato producers should use fast-food establishments as a marketing outlet. In essence, the consequences of alternative actions can be evaluated rationally.

APPENDIX A

DISCUSSION OF DATA

APPENDIX A

DISCUSSION OF DATA

Endogenous Variables

Data used in this study were compiled from many and varied sources. Not all of these sources, as may have been expected, provided data on an annual basis to fit the model construction. Consequently, some interpolations and extropolations were necessary. In these instances, trends invariably existed from which to establish missing values. A discussion of the data for each variable is provided in this section.

Although all variables are labeled and defined in Table 4.1, they are reproduced here in Table A.1 for ease of reference. The number of potato processing plants (NPP) is the sum of frozen, dehydrated and chipping plants. Annual data on chipping plants for 1960-81 were taken from the USDA Potatoes and Sweetpotatoes series. The number of frozen and dehydrated plants were reported in various scuces for the years 1961, 1964, 1972, 1978 and 1980 (Appendix B). Missing values for the years between data points were derived using a straight-line method. This method was also extended backward to 1960; an assumption of no change between 1980 and 1981 was used to derive 1981 values.

Table A.1--Variables for Analysis of Potato Industry

Endogenous Variables	
NPP	Number of processing plants
CRP	Concentration in potato processing
PCM	Price cost margins
ASR	Advertising sales ratio
CCA	Change in processing capacity
UCA	Utilization of processing capacity
QRP	Production of fresh potatoes
UZF	Utilization of potatoes for fresh consumption
UZP	Utilization of potatoes for processing
RPF	Retail price of fresh potatoes
RPP	Retail price of processed potatoes
WPP	Wholesale price of processed potatoes
FPR	Farm price of fresh potatoes
RPT	Research and promotion tax
SPR	Spread between retail and farm price
UZO	Utilization of other potatoes

Exogenous Variables	
MS	Minimum efficient plant size
PCML	Price cost margins lagged
CT	Transportation cost
GD	Geographic dispersionof potato production
CK	Cost of capital
PS	Price of sugar beets lagged
FPRL	Farm price of fresh potatoes lagged
MC	Marketing cost
TR	Trend variable
RS	Risk
GC	Produce sales through retail grocery stores
TF	Total away-from-home restaurants food sales
FF	Fast-food sales as a percent of total food
PN	Population
IN	Income
WN	Women in labor force
GR	Expected growth
UZPL	Utilization of potatoes for processing lagged
QRPL	Production of fresh potatoes lagged
ASRL	Advertising sales ratio lagged

Concentration in potato processing (CRP) represents the total share of potatoes controlled by the top four firms in frozen and potato chip production. Market shares held by the top four chipping firms were taken from the Bureau of the Census of the U.S. Department of Commerce; these data were reported on 4 to 5 year intervals for the 1958-77 period. Market shares since 1977 were collected from Snack Food and other trade publications (Appendix B). Sufficient data were reported in Quick Frozen Foods and other trade publications to derive market shares of the top four frozen potato producers on five-year intervals for the 1960-80 period (Appendix B).

Straight-line methods were used to derive missing values between reported concentration points for both frozen and chipping firms. Concentration in frozen potato production in 1981 was assumed to be unchanged from 1980. These annual concentration data were weighted by the volume of potatoes for each use to derive a concentration measure for the processed potato industry. No concentration data were reported by the Bureau of the Census for dehydrated potato processors because such data supposedly would reveal the identity of individual firms. Additionally, unlike the frozen potato sector, no trade publications provided indepth analyses of the dehydrated potato sector. Price cost margins (PCM) were defined as the difference between the wholesale price of processed potatoes (WPP) and the farm price of fresh potatoes (FPR). A complete FPR price series were collected from the USDA 1960-82 Agricultural Statistics. Some interpolations were required to derive WPP as incomplete price series were available. WPP represents a weighted-average price of frozen french fries, instant potatoes and chips.

Many sources were used to derive the WPP price series. For a complete listing, see Appendix B. The 1960 price for frozen french fries as well as instant potatoes was collected from a 1961 USDA Market Research Report. Wholesale prices of frozen french fries for 1964-71 were collected from Quick Frozen Foods; 1972-81 prices were derived using the Bureau of Labor Statistics Producer Price Index (PPI) for frozen french fries. Prices for 1961-1963 were derived from the intitutional price of frozen french fries as reported by Quick Frozen Foods. That is, the wholesale price was assumed to change in proportion to the institutional price for the 1960-63 period.

Wholesale prices for instant potatoes were collected from BLS for 1976-81. Using the 1976 price, the BLS Producer Price Index for mashed potatoes was used to derive 1968-75 prices. Prices for the remaining years, 1961-67, were derived using the ratios of the wholesale prices of mashed potatoes and frozen french fries for 1960 and 1968. That is, prices of instant potatoes were estimated assuming a straight-line method of change between stated periods and then multiplying these changes time corresponding wholesale prices of frozen french fries.

Wholesale prices of potato chips for 1960-75 were taken from a 1977 research study of the potato chip industry. Prices for 1977 and 1981 were collected from the Bureau of the Census and the Potato Chip Snack Food Management Report respectively. All remaining prices were derived using the PPI for frozen vegetables.

Given annual price data for the three product forms, WPP was derived by weighting each price by the volume of potatoes used for its form. Thus, a relatively high or low price for a form that is a small proportion of total volume would not distort WPP. It should be emphasized that these derivations are possible because of the excellent potato utilization data available in the USDA Potatoes and Sweetpotatoes series.

The advertising sales ratio (ASR) variable represents the ratio of total advertising on chips and frozen potatoes to total sales of these products. Total sales of these products were ascertained by multiplying the volume of potatoes for each use times its respective wholesale price. Advertising data for both chips and frozen potatoes were collected from Advertising Dollar Summary, National Advertising Investments and Food Field Reporter.

Advertising expenditures on chips were compiled from Food Field Reporter for 1958-61, and 1963. Comparable data for this product were reported in National Advertising Investments and Advertising Dollar Summary for 1967-81. Missing observations for years 1962 and 1963-67 were derived assuming straight-line changes between respective end values. Advertising expenditures on frozen potatoes were collected from National Advertising Investments and Advertising Dollar Summary for 1968-1981. Before 1968, there was minimal advertising of frozen potatoes. The Food Field Reporter listed expenditures of $55,000 and $29,000 for 1959 and 1961 respectively. No expenditures were reported for other years. Since advertising expenditures for the unreported years were either zero or too insignificant to report, this author has assumed the average for 1959, 1961, and 1968 prevailed. Thus, expenditures of $39,000 were included for years 1960 and 1962-67.

With the aforementioned sales and advertising data, ASR was derived by summing advertising on the two products and then dividing this sum by total sales of chips and frozen potatoes.

Change in processing capacity (CCA) is believed to be reflective of the entire potato industry, but is derived from the frozen potato sector because of unavailable data from other sectors. Data were compiled from numerous sources. For a complete listing, see Appendix B. Industry capacity data were reported for years 1960, 1963 and 1981. These capacity figures were used as check points against the totality of expanded and new plant capacities. That is, this author meticulously examined trade-related publications to ascertain plant expansions and additions. These figures invariably approximated those reported by industry officials in the aforementioned years. Having derived total capacity for each year, CCA was derived by getting the percent changed from year to year.

Utilization of processing capacity (UCA), just as CCA, was derived solely from the frozen potato sector. This variable represents the ratio of total production of frozen potatoes to total capacity. Total production data were collected from the Quick Frozen Foods series. Total capacity data were compiled as previously described.

Production of fresh potatoes (QRP) represents quantities of potatoes harvested within a given year. These data were collected from the USDA Potatoes and Sweetpotatoes series. Although the data represents quantities harvested rather than produced, over 85 percent of all quantities are both produced and harvested within the reported year.

Utilization of potatoes for fresh consumption (UZF) and processing (UZP) are simply distribution of QRP. These data are reported in the same source and on the same basis, calendar year, as that of QRP. It should be emphasized that these two uses do not exhaust the distribution of QRP. The remaining quantities are used for seed and feed or lost to shrinkage. These quantities were aggregated into utilization of other potatoes (UZO). Complete data series on all these uses were collected from Potatoes and Sweetpotatoes.

Focusing now on potato prices, this study utilizes three series--farm, wholesale and retail. The farm price of fresh potatoes (FPR) represents the price received at the farm irrespective of the final use of the potato. Data for this variable were collected from the USDA Agricultural Statistics series. These data are reported on an annual basis and represent weighted averages of monthly prices. The wholesale price of processed potatoes (WPP) and its related data were discussed earlier with reference to PCM.

The retail price of processed potatoes (RPP) is a combination of retail prices of frozen and dehydrated potatoes. The method of derivation is comparable to that for WPP with the exception that chip prices are excluded. Unfortunately, the Bureau of Labor Statistics only recently began to provide potato chip prices at the retail level.

Retail prices of frozen french fries were collected from BLS for 1960-81, but no price was reported for 1979. This observation was derived assuming the retail and wholesale prices of french fries bore the same relation as in 1978. Ascertaining retail prices of dehydrated potatoes was a bit more cumbersome. The 1960 price was taken from a 1961 USDA Market Research Report. Prices for 1964-78 were collected from the Retail Price series of the Bureau of Labor Statistics. Missing observations for 1961-63 and 1979-81 were derived using respectively the CPI for processed fruits and vegetables and processed vegetables. Different indexes were used because BLS only separated out processed vegetables in 1968. This price series together with that of frozen french fries was used, as previously described, to derive BPP.

The last endogenous variable for which data were collected is the research and promotion tax on potatoes (RPT). Data were collected from USDA Agricultural Marketing Service (AMS). Because these data represented a one cent tax on potatoes used for food and seed, they could also be generated since these potato uses are integral parts of the model. This latter procedure was specified and the revenues generated closely approximated those reported by AMS. To gain some efficiency, this author generated RPT internally.

One remaining endogenous variable which did not require any data collection is the spread between retail and farm prices of fresh potatoes (SPR). This variable was specified for estimation purposes only. Given the two price series, its derivation is straight forward and apparent.

Exogenous Variables

While eclectic sources and procedures were used to compile data for many endogenous variables, data for most exogenous variables were accessible from a minimal number of sources. A further ease of burden in compiling data for the exogenous variables resulted from the fact that several are simply lagged endogenous variables.

Appropriately, the first exogenous variable discussed, minimum efficient plant size (MS), is one for which obtaining data was most difficult. Sufficient data were availble to compile a reliable series for the frozen potato sector only. MS therefore represents the average per hour production capacity of frozen potato plants constructed within a given year. When no new plant construction was reported, plant sizes of the previous year were assumed. Data were collected from the same sources as were data for CCA.

The cost of transporting potatoes (CT) is measured as the average cost of diesel fuel. Data for 1960-81 were calculated from various U.S. Department of Energy publications (Appendix B). The geographic dispersion of potato production (GD) is a measure of shifts in production of fresh potatoes. Data were collected from USDA Potatoes and Sweetpotatoes series. These data, reported by states, were aggregated into eight regions. A measure of concentration utilizing the Herfindal index was derived from the production data of the regions (Appendix B).

Marketing cost of potatoes (MC) is measured as the total food marketing cost index. This proxy was necessitated by the lack of systematic data on marketing cost of potatoes. Data for 1960-67 were collected from the USDA Agricultural Outlook series. All remaining observations were taken from USDA 1982 Food Consumption, Prices and Expenditures.

Potato producers are naturally subjected to some risk (RS). To quantify this concept, RS is defined as the coefficient of variation of monthly potato prices. Monthly price data for 1960-80 were collected from the Commodity

Yearbook series. USDA Annual Summary of Agricultural Prices were used to collect 1981 monthly prices. See Appendix B for a definition of the coefficient of variation.

Total away-from-home restaurant food sales (TF) and fast-food sales as a ratio of total away-from-home sales (FF) were also variables with missing observations. Data were collected for both TF and FF from the Bureau of the Census of the U.S. Department of Commerce. Before 1967, expenditures on TF were reported on 4-5 year intervals. A straight-line method was used to estimate these missing observations. Expenditures at fast-food restaurants were reported on 4-5 year intervals until 1977. Missing values were derived by regressing the reported fast food sales against total food sales (Appendix B). The variable FF was then defined as the ratio of fast-food sales to total food sales.

Complete data series were collected for all remaining variables. The cost of capital (CK) was defined as the U.S. prime interest rate. These data were collected from the 1983 Economic Report of the President. Data on the price of sugar beets (PS) were collected from the USDA Agricultural Statistics series. Produce sales through retail grocery stores (GC) were collected from the Supermarket Business series. Population (PN) and income (IN) data were gathered from U.S. Historical Statistics and Survey of Current Business reports.

Women in the labor force (WN) is defined as the percentage of women in total labor force. These data were collected from the Handbook of Labor Statistics and Employment and Earnings of the Bureau of Labor Statistics. Expected growth (GR) was defined as a three period lag of UZP with equal weights per period. Only the UZP data were required to derive this variable. A trend variable (TR) was defined simply as the years of the data period, 1960-81. All remaining exogenous variables are lagged endogenous variables, requiring, of course, the previously described data.

Several price indexes were used to quantify data in real terms. These included the: Producer Price Index for All Items (PPAI), Consumer Price Index for All Items (CPAI), Consumer Price Index for All Food (CPAF), and Consumer Price Index for Food Away From Home (CPAH). Data on all these indexes were compiled from the 1982 USDA Food Consumption, Prices and Expenditures report.

APPENDIX B

DATA SOURCES

APPENDIX B
DATA SOURCES

Specific Variables

NPP Number of Potato Processing Plants

Data on the number of Frozen and Dehydrated plants were collected from the sources below.

1961--An Economic Study of the U.S. Potato Industry. USDA, ERS, Agricultural Economic Report No. 6, 1962.

1964--Demand and Price Analysis for Potatoes. USDA, ERS, Technical Bulletin No. 1380, 1967.

1972--Report of the Potato Processing Study Group. USDA, July 1974.

1978 and 1980--A listing of frozen and dehydrated plants sent to this author from officials knowledgeable of potato industry.

CRP Concentration in Potato Processing

In addition to the 1958-77 market shares internal data on potato chip firms collected from the Bureau of the Census, comparable 1982 data were collected from 1980-83 volumes of: Chipper/Snacker, Food Engineering, Moody's Industrial Manual, Snack Food and Who's Who in the Snack Food Industry. Missing observations were then derived using a straight-line method.

Market shares data on the top four firms in frozen potato production were collected on five-year intervals for the 1960-80 period. The numerous sources used were: Canner Packer, Food Engineering, Food Processing, Moody's Industrial Manual, Processed Prepared Foods, Quick Frozen Foods and published papers of the Annual Potato Utilization Conferences. Missing observations among these 1960-80 data were derived using a straight-line method between each set of end values. The 1981 value was derived using the assumption of no change in concentration between 1980 and 1981.

WPP Wholesale Price of Processed Potatoes

Data sources were as follows: Potato chip prices for 1960-75 were compiled from a study by Jeffery Goldberd entitled The Potato Chip Market: An Economic-Marketing Financial Investigation Analysis, 1978. This study did not report a 1969 price so it was derived as the average of the 1968 and 1970 price. The 1977 potato chip price was collected from the Bureau of the Census of the U.S. Department of Commerce. The Potato Chip Snack Food 1982 Management Report was used to compile the 1981 price. All remaining chip prices were derived using the PPI for frozen vegetables.

The 1960 wholesale price of frozen french fries was collected from a 1961 USDA Market Research Report entitled Market Potential for Processed Potato Products, No. 505. Frozen french fries prices for 1964-71 were compiled from the monthly wholesale price reports of Quick Frozen Foods.

These monthly prices were averaged to derive annual prices. In addition to these monthly wholesale prices, this publication also reported annual institutional prices of frozen french fries. That is, the price for which institutional establishments brought frozen french fries from frozen potato processors. This price series was used to derive 1961-63 wholesale prices of frozen french fries. The Producer Price Index for frozen french fries as reported by BLS was used to derive 1972-81 prices.

The 1960 wholesale price of instant potatoes was collected from the same source as was that of frozen french fries. BLS reported 1976-81 prices as well as a PPI for instant potatoes for the 1968-81 period. This index was used to derive 1968-75 prices. The remaining 1961-67 prices were derived using the relationship of the wholesale prices of mashed potatoes and frozen french fries for 1960 and 1968.

CCA Change in Processing Capacity

Data sources included: American Vegetable Grower, Canner Packer, Food Engineering, Food Processing, Processed Prepared Foods and published papers of the Annual Potato Utilization Conferences.

CT Transportation Cost

Data were collected from the following sources:
1960-77--State Energy Fuel Price by Major Economic Sector, U.S. Department of Energy, 1978.

1978-79--Monthly Petroleum Produce Price Report, EIA, U.S. Department of Energy, July, 1979.

1980--State Energy Price System Final Report, Vol. I, EIA, U.S. Department of Energy, Nov. 1982.

1981--Monthly Petroleum Producet Price Report, EIA, U.S. Department of Energy, Dec. 1982.

GD Geographic Dispersion of Potato Production

The states' production data from USDA Potatoes and Sweetpotatoes series were aggregated into eight regions as follows:

Region 1--Conn., Me., Mass., N.H., N.Y., Penn., R.I., Vt.

Region 2--Del., Md., N.J., N.C., Va.

Region 3--Ga., Ala., Fla., La., Miss., S.C., W.Va., Ky., Tenn.

Region 4--Ill., Ind., Mich., Oh., Wis.

Region 5--Minn., N.D.

Region 6--Id., Ore., Wash.

Region 7--Ca., Nev.

Region 8--Ark., Ariz., Colo., Ia., S.D., Mont., Neb., N.M., Tex., Ut., Wy., Okla., Mo., Ks.

Data from these regions were then used to derive a measure of dispersion of potato production. A variant of the Herfindal index as defined below was used.

$GD = 1 - \sum_{i=1}^{8} R_i^2$ where R_i = region's share of total production.

RS Risk

Given monthly potato prices for 1960-81, the coefficient of variation formula below was used to quantify the level of risk.

$$\sum_{i=1960}^{1981} RS_i = \frac{s}{\bar{p}} \cdot 100$$ where s is the standard deviation and $\bar{p}$ is the arithmetic mean of monthly prices.

TF Total Away-From-Home Restaurant Food Sales

Data were compiled from the Census of Retail Trade and Commerce Business Reports of the U.S. Department of Commerce. These data were reported fo 1958, 1963 and 1967-81. A straight-line method was used to generate missing observations.

FF Fast-Food as Percent of Total Away-From-Home Food Sales

The above sources from which data on TF were collected also reported fast-food sales for 1958, 1963, 1967, 1972 and 1977-81. The derivation of annual fast-food sales from this data was as follows. The first five observations (1958-77) of fast food sales were regressed (logs) against their corresponding TF observations (logs). The resulting equation was then used to derive missing observations. These annual data were then divided by their corresponding TF values to derive FF.

APPENDIX C

RAW DATA AND SOME EMPIRICAL RESULTS

Table C.1--States Comprising Potato Production Regions

Central	Southeast	Northeast
Arkansas	Alabama	Connecticut
Arizona	Georgia	Maine
Colorada	Florida	Massachusetts
Iowa	Louisiana	New Hampshire
South Dakota	Mississippi	New York
Montana	South Carolina	Pennsylvania
Nebraska	West Virginia	Rhode Island
New Mexico	Kentucky	Vermont
Texas	Tennessee	
Utah		
Wyoming		
Oklahoma		
Missouri		
Kansas		

Middle Atlantic	Lake States	Pacific Northwest
Delaware	Illinois	Idaho
Maryland	Indiana	Oregon
Ney Jersey	Michigan	Washington
North Carolina	Ohio	
Virginia	Wisconsin	

Red River Valley	California/Nevada
Minnesota	California
North Dakota	Nevada

Table C.2--Principal Components Analysis

Components from All Exogenous Variables

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
PRIN1	14.18939	11.87774	0.70947	0.70947
PRIN2	2.31165	0.86612	0.11558	0.82505
PRIN3	1.44553	0.63196	0.07228	0.89733
PRIN4	0.81357	0.16069	0.04068	0.93801
PRIN5	0.65288	0.47486	0.03264	0.97065
PRIN6	0.17802	0.03710	0.00890	0.97955
PRIN7	0.14092	0.02849	0.00705	0.98660
PRIN8	0.11243	0.04299	0.00562	0.99222
PRIN9	0.06944	0.02294	0.00347	0.99569
PRIN10	0.04649	0.03082	0.00232	0.99802
PRIN11	0.01568	0.00601	0.00078	0.99880
PRIN12	0.00967	0.00444	0.00048	0.99928
PRIN13	0.00523	0.00102	0.00026	0.99954
PRIN14	0.00421	0.00224	0.00021	0.99975
PRIN15	0.00197	0.00031	0.00010	0.99985
PRIN16	0.00166	0.00108	0.00008	0.99994
PRIN17	0.00058	0.00019	0.00003	0.99996
PRIN18	0.00038	0.00007	0.00002	0.99998
PRIN19	0.00032	0.00032	0.00002	1.00000
PRIN20	0.00000	.	0.00000	1.00000

Components from Equation 4.1

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
AAA1	6.654507	6.030330	0.831813	0.831813
AAA2	0.624177	0.328477	0.078022	0.909835
AAA3	0.295700	0.120454	0.036963	0.946798
AAA4	0.175246	0.021623	0.021906	0.968704
AAA5	0.153622	0.091409	0.019203	0.987906
AAA6	0.062214	0.035509	0.007777	0.995683
AAA7	0.026705	0.018875	0.003338	0.999021
AAA8	0.007830	.	0.000979	1.000000

Components from Equation 4.2

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
BBB1	4.998000	3.672035	0.714000	0.714000
BBB2	1.325965	1.059231	0.189424	0.903424
BBB3	0.266734	0.064147	0.038105	0.941529
BBB4	0.202587	0.087596	0.028941	0.970470
BBB5	0.114991	0.044867	0.016427	0.986897
BBB6	0.070124	0.048525	0.010018	0.996914
BBB7	0.021599	.	0.003086	1.000000

Table C.2--Continued

Components from Equation 4.3

```
          EIGENVALUE      DIFFERENCE      PROPORTION      CUMULATIVE

CCC1        2.662253        2.400088        0.887418        0.887418
CCC2        0.262165        0.186583        0.087388        0.974806
CCC3        0.075582            .           0.025194        1.000000
```

Components from Equation 4.4

```
          EIGENVALUE      DIFFERENCE      PROPORTION      CUMULATIVE

DDD1        5.453736        5.193840        0.908956        0.908956
DDD2        0.259896        0.103330        0.043316        0.952272
DDD3        0.156565        0.079878        0.026094        0.978366
DDD4        0.076688        0.036036        0.012781        0.991147
DDD5        0.040651        0.028187        0.006775        0.997923
DDD6        0.012465            .           0.002077        1.000000
```

Components from Equation 4.5

```
          EIGENVALUE      DIFFERENCE      PROPORTION      CUMULATIVE

EEE1        3.207472        2.796923        0.801868        0.801868
EEE2        0.410550        0.165732        0.102637        0.904505
EEE3        0.244818        0.107657        0.061204        0.965710
EEE4        0.137160            .           0.034290        1.000000
```

Components from Equation 4.6

```
          EIGENVALUE      DIFFERENCE      PROPORTION      CUMULATIVE

FFF1        3.377015        3.013559        0.844254        0.844254
FFF2        0.363457        0.157380        0.090864        0.935118
FFF3        0.206076        0.152625        0.051519        0.986637
FFF4        0.053451            .           0.013363        1.000000
```

Table C.2--Continued

Components from Equation 4.8

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
GGG1	6.498380	5.547684	0.812297	0.812297
GGG2	0.950696	0.530783	0.118837	0.931134
GGG3	0.419913	0.326727	0.052489	0.983624
GGG4	0.093186	0.070473	0.011648	0.995272
GGG5	0.022713	0.011936	0.002839	0.998111
GGG6	0.010777	0.007833	0.001347	0.999458
GGG7	0.002944	0.001551	0.000368	0.999826
GGG8	0.001393	.	0.000174	1.000000

Components from Equation 4.9

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
HHH1	7.739645	6.772042	0.773964	0.773964
HHH2	0.967602	0.229574	0.096760	0.870725
HHH3	0.738028	0.472888	0.073803	0.944528
HHH4	0.265140	0.080939	0.026514	0.971042
HHH5	0.184201	0.099278	0.018420	0.989462
HHH6	0.084923	0.073920	0.008492	0.997954
HHH7	0.011003	0.004917	0.001100	0.999054
HHH8	0.006087	0.003818	0.000609	0.999663
HHH9	0.002269	0.001167	0.000227	0.999890
HHH10	0.001102	.	0.000110	1.000000

Table C.3—Principal Component Equations

```
PROC SYSREG DATA=SPUD OUT=CHIPS OUTEST=FRIES;
   BLOCK NPP CRP PCM ASR CCA UCA GRP  UZF UZP RPF RPP WPP FPR  SPR
     BARA1 BARA2 BARB1 BARB2 BARC1 BARC2 BARD1 BARD2 BARE1 BARE2 BARF1
     BARF2 BARG1 BARG2 BARG3 BARH1 BARH2 BARH3=PRIN1 PRIN2 PRIN3 PRIN4
     PRIN5;
EQ01: MODEL NPP=BARA1 BARA2 CARA1 CARA2;
RESTRICT BARA1-CARA1, BARA2-CARA2;
EQ02: MODEL CRP=BARB1 BARB2 CARB1 CARB2;
RESTRICT BARB1-CARB1, BARB2-CARB2;
EQ03: MODEL PCM=BARC1 BARC2 CARC1 CARC2;
RESTRICT BARC1-CARC1, BARC2-CARC2;
EQ04: MODEL ASR=BARD1 BARD2 CARD1 CARD2;
RESTRICT BARD1-CARD1, BARD2-CARD2;
EQ05: MODEL CCA=BARE1 BARE2 CARE1 CARE2;
RESTRICT BARE1-CARE1, BARE2-CARE2;
EQ06: MODEL UCA=BARF1 BARF2 CARF1 CARF2;
RESTRICT BARF1-CARF1, BARF2-CARF2;
EQ07: MODEL GRP=RS TR PS  FPRL GRPL;
RESTRICT GRPL=1;
EQ08: MODEL UZF=BARG1 BARG2 BARG3 CARG1 CARG2 CARG3;
RESTRICT BARG1-CARG1, BARG2-CARG2, BARG3-CARG3;
EQ09: MODEL UZP=BARH1 BARH2 BARH3 CARH1 CARH2 CARH3;
RESTRICT BARH1-CARH1, BARH2-CARH2, BARH3-CARH3;
EQ11: MODEL RPP=WPP TR ;
EQ13: MODEL FPR=GRP GRPL;
EQ15: MODEL SPR=MC;
SYSTEM EQ01 EQ02 EQ03 EQ04 EQ05 EQ06 EQ07 EQ08 EQ09 EQ11 EQ13 EQ15;
RESTRICT EQ01.BARA1-EQ01.CARA1=0,
   EQ01.BARA2-EQ01.CARA2,
   EQ02.BARB1-EQ02.CARB1,
   EQ02.BARB2-EQ02.CARB2,
   EQ03.BARC1-EQ03.CARC1,
   EQ03.BARC2-EQ03.CARC2,
   EQ04.BARD1-EQ04.CARD1,
   EQ04.BARD2-EQ04.CARD2,
   EQ05.BARE1-EQ05.CARE1,
   EQ05.BARE2-EQ05.CARE2,
   EQ06.BARF1-EQ06.CARF1,
   EQ06.BARF2-EQ06.CARF2,
EQ07.GRPL=1,
   EQ08.BARG1-EQ08.CARG1,
   EQ08.BARG2-EQ08.CARG2,
   EQ08.BARG3-EQ08.CARG3,
   EQ09.BARH1-EQ09.CARH1,
   EQ09.BARH2-EQ09.CARH2,
   EQ09.BARH3-EQ09.CARH3;
  IDENTITY RPF=FPR+SPR;
  IDENTITY WPP=FPR+PCM;
  IDENTITY GRP=UZF + UZP + UZO;
IDENTITY BARA1= -.2132*PCM +4.0896*UCA  -1.1646;
IDENTITY BARA2=  .2870*PCM +.4119*UCA  - 1.9187;
IDENTITY BARB1=  -.0049*NPP +120.3035*ASR +.5267;
IDENTITY BARB2=  -.0012*NPP -205.4800*ASR +2.4901;
IDENTITY BARC1=  .1431*CRP +6.6497*UCA -13.1622;

IDENTITY BARC2= .0467*CRP + 6.5619*UCA -6.8871;
IDENTITY BARD1= .0975*CRP -.0327*UZF + .0270*UZP -5.8679;
IDENTITY BARD2=  .0561*CRP -.0230*UZF -.0192*UZP -1.0305;
IDENTITY BARE1=  .0061*NPP - 5.3483*UCA +1.2955;
IDENTITY BARE2=  -.0008*NPP -2.7794*UCA +1.9265;
IDENTITY BARF1=  .0059*NPP + 7.2587*CCA - .0345*UZP -.6416;
IDENTITY BARF2=  .0005*NPP +12.5912*CCA +.0179*UZP -2.3892;
IDENTITY BARG1=  .1192*RPF -.2058*RPP     +1.3446;
IDENTITY BARG2=  1.0544*RPF -.0709*RPP     -7.6355;
IDENTITY BARG3=  .1947*RPF +.5434*RPP     -7.6225;
IDENTITY BARH1=  109.3100*ASR +.1096*RPF -.1961*RPP     +.2199;
IDENTITY BARH2=  21.6281*ASR +1.0024*RPF -.0976*RPP     -7.1379;
IDENTITY BARH3=  -208.3842*ASR +.3590*RPF +.2554*RPP     -3.6373;
```

Table C.3--Continued

```
BARA1= -.333012/1.5616*(PCM-5.8404) + .355798/.0869*(UCA-.5893);
BARA2=  .448140/1.5616*(PCM-5.8404) + .035836/.0869*(UCA-.5893);
BARB1= -.425398/86.7374*(NPP-352.6818) +.312789/.0026*(ASR-.0100);
BARB2= -.107057/86.7374*(NPP-352.6818) -.534248/.0026*(ASR-.0100);
BARC1= .595522/4.1627*(CRP-64.6097) +.577861/.0869*(UCA-.5893655);
BARC2= .194587/4.1627*(CRP-64.6097) +.570227/.0869*(UCA-.5893655);
BARD1= .405935/4.1627*(CRP-64.6097) -.413032/12.6258*(UZF-62.7664)
 +.412597/15.2643*(UZP-59.9550);
BARD2= .233703/4.1627*(CRP-64.6097) -.290689/12.6258*(UZF-62.7664)
 -.293208/15.2643*(UZP-59.9550);
BARE1= .528976/86.7374 *(NPP-352.6818)  -.508213/.0869*(UCA-.5893);
BARE2= -.070966/86.7374*(NPP-352.6818) -.241529/.0869*(UCA-.5893);
BARF1= .507601/86.7374*(NPP-352.6818) + .466737/.0643*(CCA-.0891)
 -.526775/15.2643*(UZP-59.9550);
BARF2= .046424/86.7374*(NPP-352.6818) +.809617/.0643*(CCA-.0891)
 +.274602/15.2643*(UZP-59.9550);
BARG1= .110401/.9264*(RPF-7.9919) -.322737/1.5684*(RPP-11.1635) ;
BARG2= .976801/.9264*(RPF-7.9919) -.111171/1.5684*(RPP-11.1635) ;
BARG3= .180354/.9264*(RPF-7.9919) +.852367/1.5684*(RPP-11.1635) ;
BARH1=.284206/.0026*(ASR-.0100) + .101509/.9264*(RPF-7.9919)
 -.307511/1.5684*(RPP-11.1635) ;
BARH2= .056233/.0026*(ASR-.0100) +.928657/.9264*(RPF-7.9919) -
 .153118/1.5684*(RPP-11.1635) ;
BARH3= -.541799/.0026*(ASR-.0100) +.332622/.9264*(RPF-7.9919) +
 .400657/1.5684*(RPP-11.1635) ;
CARA1=.380586/12.0115*(MS-23.2954) + .380954/17.0775*(GR-55.8522)
 - .372272/.0399*(GD-.7754) + .286039/7.63904*(CT-21.2667)
 -.341236/1.6923*(PCML-6.0325) +.368365/16.4230*(UZPL-57.7815);
CARA2= .132854/12.0115*(MS-23.2954) - .036252/17.0775*(GR-55.8522)
 -.098603/.0399*(GD-.7754) + .797379/7.63904*(CT-21.2667)
 +.340155/1.6923*(PCML-6.0325) -.132972/16.4230*(UZPL-57.7815);
CARB1= .440783/12.0115*(MS-23.2954) + .359673/3.7779*(CK-7.6354)
 + .346471/7.6390*(CT-21.2667) -.398749/1.6923*(PCML-6.0325) +
 .344241/.0028*(ASRL-.0097);
CARB2= .030824/12.0115*(MS-23.2954) +.454324/3.7779*(CK-7.6354)
 +.513619/7.6390*(CT-21.2667) + .211930/1.6923*(PCML-6.0325) -
  .432479/.0028*(ASRL-.0097);
CARC1= -.558060/1.6923*(PCML-6.0325);
CARC2= .798109/1.6923*(PCML-6.0325);
CARD1= .420332/17.0775*(GR-55.8522) - .408888/.0399*(GD-.7754)
 -.387966/1.6923*(PCML-6.0325);
CARD2= .220402/17.0775*(GR-55.8522) - .300394/.0399*(GD-.7754)
 +.797558/1.6923*(PCML-6.0325);
CARE1= .486687/1.6923*(PCML-6.0325) - .474393/3.7779*(CK-7.6354);
CARE2= .580044/1.6923*(PCML-6.0325) + .774710/3.7779*(CK-7.6354);
CARF1= .496997/1.6923*(PCML-6.0325);
CARF2= -.516881/1.6923*(PCML-6.0325);
CARG1= .369430/.0413*(GC-.6785) +.385625/5242.15*(TF-22022.49)
 +.386348/.0910*(FF-.2517) + .390119/14.7301*(PN-206.050)
 +.385033/396.233*(IN-2882.277) + .385695/.0334*(WN-.37027);
CARG2= -.113954/.0413*(GC-.6785) -.076232/5242.15*(TF-22022.49)
 - .069510/.0910*(FF-.2517) -.051547/14.7301*(PN-206.05)
 +.017636/396.233*(IN-2882.277) -.083098/.0334*(WN-.3702);
CARG3= .294989/.0413*(GC-.6785) +.223291/5242.15*(TF-22022.49)
 +.067723/.0910*(FF-.2517) +.086475/14.7301*(PN-206.05)
 -.214410/396.233*(IN-2882.277) + .214546/.0334*(WN-.3702);
CARH1= .329202/.0413*(GC-.6785) +.347751/5242.15*(TF-22022.49)
 +.350850/.0910*(FF-.2517) +.352787/14.7301*(PN-206.05) +
  .357508/396.233*(IN-2882.277) + .344985/.0334*(WN-.3702) +
 .301123/.0028*(ASRL-.0097);
CARH2= -.172133/.0413*(GC-.6785) -.120957/5242.15*(TF-22022.49)
 -.103236/.0910*(FF-.2517) -.091221/14.7301*(PN-206.05)
 +.016141/396.233*(IN-2882.2777) -.136637/.0334*(WN-.3702) +
 .169819/.0028*(ASRL-.0097);
CARH3= .310092/.0413*(GC-.6785) +.232946/5242.15*(TF-22022.49)
 +.134325/.0910*(FF-.2517) +.175431/14.7301*(PN-206.05)
 -.071971/396.233*(IN-2882.277) +.276479/.0334*(WN-.3702) -
 .392976/.0028*(ASRL-.0097);
```

Table C.4—Second and Third Stage Estimates

```
MODEL:    EQ01                      SSE      9755.951        F RATIO         146.09
                                    DFE            19        APPROX PR>F     0.0001
DEP VAR: NPP                        MSE    513.471114        R-SQUARE        0.9389
                                    OBJ      7961.895

SECOND STAGE STATISTICS

                                PARAMETER      STANDARD                       APPROX
VARIABLE              DF         ESTIMATE         ERROR        T RATIO      PROB>|T|

INTERCEPT              1       352.701123      4.831107        73.0063        0.0001
B001.BARA1             1       -32.201466      1.919850       -16.7729        0.0001
B001.BARA2             1       -20.208364      6.463145        -3.1267        0.0056
CARA1                  1       -32.201466      1.919850       -16.7729        0.0001
CARA2                  1       -20.208364      6.463145        -3.1267        0.0056

RESTRICTION           -1         9.579771      7.574522         1.2647        0.2213
RESTRICTION           -1        -6.168720     11.115671        -0.5550        0.5854
------------------------------------------------------------------------------------

MODEL:    EQ02                      SSE     36.416174        F RATIO          85.77
                                    DFE            19        APPROX PR>F     0.0001
DEP VAR: CRP                        MSE      1.916641        R-SQUARE        0.9003
                                    OBJ     35.114203

SECOND STAGE STATISTICS

                                PARAMETER      STANDARD                       APPROX
VARIABLE              DF         ESTIMATE         ERROR        T RATIO      PROB>|T|

INTERCEPT              1        64.606934      0.295162       218.8865        0.0001
B001.BARB1             1         1.762704      0.134611        13.0948        0.0001
B001.BARB2             1         0.073383      0.270631         0.2712        0.7892
CARB1                  1         1.762704      0.134611        13.0948        0.0001
CARB2                  1         0.073383      0.270631         0.2712        0.7892

RESTRICTION           -1         0.294118      0.792422         0.3712        0.7146
RESTRICTION           -1        -0.391326      0.576678        -0.6786        0.5056
------------------------------------------------------------------------------------

MODEL:    EQ03                      SSE     12.145062        F RATIO          29.89
                                    DFE            19        APPROX PR>F     0.0001
DEP VAR: PCM                        MSE      0.639214        R-SQUARE        0.7586
                                    OBJ     12.996482

SECOND STAGE STATISTICS

                                PARAMETER      STANDARD                       APPROX
VARIABLE              DF         ESTIMATE         ERROR        T RATIO      PROB>|T|

INTERCEPT              1         5.840385      0.170456        34.2633        0.0001
B001.BARC1             1        -0.821626      0.110156        -7.4587        0.0001
B001.BARC2             1         0.442919      0.428144         1.0345        0.3139
CARC1                  1        -0.821626      0.110156        -7.4587        0.0001
CARC2                  1         0.442919      0.428144         1.0345        0.3139

RESTRICTION           -1        -0.031919      0.056165        -0.5683        0.5765
RESTRICTION           -1         0.045648      0.080324         0.5683        0.5765
------------------------------------------------------------------------------------

MODEL:    EQ04                      SSE .00005670304         F RATIO          14.66
                                    DFE           19         APPROX PR>F     0.0001
DEP VAR: ASR                        MSE .00000298437         R-SQUARE        0.6069
                                    OBJ .00005952102

SECOND STAGE STATISTICS

                                PARAMETER      STANDARD                       APPROX
VARIABLE              DF         ESTIMATE         ERROR        T RATIO      PROB>|T|

INTERCEPT              1         0.010004 0.0003683113         27.1619        0.0001
B001.BARD1             1 0.0008656187 0.0001617258              5.3524        0.0001
B001.BARD2             1 -0.000617246    0.000743977           -0.8297        0.4170
CARD1                  1 0.0008656187 0.0001617258              5.3524        0.0001
CARD2                  1 -0.000617246    0.000743977           -0.8297        0.4170

RESTRICTION           -1 -0.000207977    0.000479202           -0.4340        0.6692
RESTRICTION           -1 -0.000740387 0.0007035662             -1.0523        0.3058
```

Table C.4--Continued

```
------------------------------------------------------------------------------------------

MODEL:    E005                        SSE       0.032004        F RATIO             15.66
                                      DFE             15        APPROX PR>F        0.0001
DEP VAR: CCA                          MSE    0.001634413        R-SQUARE           0.6224
                                      OBJ       0.034125

SECOND STAGE STATISTICS

                                 PARAMETER      STANDARD                            APPROX
VARIABLE               DF         ESTIMATE         ERROR            T RATIO       PROB>|T|

INTERCEPT               1         0.099203   0.009750098            10.1945         0.0001
B001.BARE1              1         0.027889   0.005007909             5.3691         0.0001
B001.BARE2              1      0.008701073      0.014017             0.6208         0.5421
CARE1                   1         0.027889   0.005007909             5.3691         0.0001
CARE2                   1      0.008701078      0.014017             0.6208         0.5421

RESTRICTION            -1         0.054703      0.036034             1.5181         0.1455
RESTRICTION            -1      0.005233452   0.008264037             0.6333         0.5341
------------------------------------------------------------------------------------------

MODEL:    E006                        SSE       0.035226        F RATIO             33.60
                                      DFE             19        APPROX PR>F        0.0001
DEP VAR: UCA                          MSE    0.001354016        R-SQUARE           0.7796
                                      OBJ       0.034372

SECOND STAGE STATISTICS

                                 PARAMETER      STANDARD                            APPROX
VARIABLE               DF         ESTIMATE         ERROR            T RATIO       PROB>|T|

INTERCEPT               1         0.589422   0.009180096            64.2066         0.0001
B001.BARF1              1        -0.042666   0.005205032            -8.1971         0.0001
B001.BARF2              1        -0.024517      0.023363            -1.0494         0.3072
CARF1                   1        -0.042666   0.005205032            -8.1971         0.0001
CARF2                   1        -0.024517      0.023363            -1.0494         0.3072

RESTRICTION            -1        -0.023604      0.013820            -1.7079         0.1039
RESTRICTION            -1         0.024539      0.014368             1.7079         0.1039
------------------------------------------------------------------------------------------

MODEL:    E007                        SSE       1035.939        F RATIO              4.43
                                      DFE             17        PROB>F             0.0123
DEP VAR: CRP                          MSE      60.937614        R-SQUARE           0.5106

                                 PARAMETER      STANDARD
VARIABLE               DF         ESTIMATE         ERROR            T RATIO       PROB>|T|

INTERCEPT               1      -496.138296    570.785554            -0.8692         0.3968
RS                      1        -0.330856      0.230253            -1.4369         0.1689
TR                      1         0.239591      0.290489             0.8248         0.4209
PS                      1       -19.100858      9.894984            -1.9304         0.0704
FFRL                    1        20.565393      3.358767             6.1229         0.0001
ORPL                    1         1.000000   1.81754E-09         99999.0000         0.0001

RESTRICTION            -1      -446.765209    230.229126            -1.9405         0.0691


MODEL:    E008                        SSE     137.159535        F RATIO            135.14
                                      DFE             18        APPROX PR>F        0.0001
DEP VAR: UZF                          MSE       7.619974        R-SQUARE           0.9575
                                      OBJ     258.422925

SECOND STAGE STATISTICS

                                 PARAMETER      STANDARD                            APPROX
VARIABLE               DF         ESTIMATE         ERROR            T RATIO       PROB>|T|

INTERCEPT               1        62.766854      0.588526           106.6509         0.0001
B001.BARG1              1        -4.764972      0.236928           -20.1115         0.0001
B001.BARG2              1         0.248480      0.677502             0.3668         0.7181
B001.BARG3              1         2.360367      1.237729             1.9070         0.0726
CARG1                   1        -4.764972      0.236928           -20.1115         0.0001
CARG2                   1         0.248480      0.677502             0.3668         0.7181
CARG3                   1         2.360367      1.237729             1.9070         0.0726

RESTRICTION            -1         0.672716      0.237013             2.8383         0.0109
RESTRICTION            -1         0.402383      0.143992             2.7945         0.0120
RESTRICTION            -1        -1.690890      0.595914            -2.8375         0.0109
```

Table C.4--Continued

```
-------------------------------------------------------------------------------------------

MODEL:     EG09                   SSE    354.778462        F RATIO           77.27
                                  DFE            18        APPROX PR>F      0.0001
DEP VAR: UZR                      MSE     19.709915        R-SQUARE         0.9279
                                  OBJ    324.255904

SECOND STAGE STATISTICS

                                 PARAMETER      STANDARD                      APPROX
VARIABLE             DF          ESTIMATE         ERROR          T RATIO     PROB>|T|

INTERCEPT             1         59.939011      0.946525         63.3254       0.0001
B001.BARH1            1          5.289486      0.348332         15.1852       0.0001
B001.BARH2            1          0.684467      1.073932          0.6373       0.5319
B001.BARH3            1         -1.318084      1.221517         -1.0791       0.2948
CARH1                 1          5.289486      0.348332         15.1852       0.0001
CARH2                 1          0.684467      1.073932          0.6373       0.5319
CARH3                 1         -1.318084      1.221517         -1.0791       0.2948

RESTRICTION          -1          1.764169      1.472674          1.1979       0.2465
RESTRICTION          -1          1.079851      1.007045          1.0723       0.2978
RESTRICTION          -1         -2.299714      2.207476         -1.0418       0.3113
-------------------------------------------------------------------------------------------

MODEL:     EG11                   SSE     11.162141        F RATIO           33.36
                                  DFE            19        APPROX PR>F      0.0001
DEP VAR: RPP                      MSE      0.587481        R-SQUARE         0.7783
                                  OBJ     12.468859

SECOND STAGE STATISTICS

                                 PARAMETER      STANDARD                      APPROX
VARIABLE             DF          ESTIMATE         ERROR          T RATIO     PROB>|T|

INTERCEPT             1       -333.167038    191.700170         -1.7380       0.0984
E001.WPP              1          1.771847      0.461207          3.8418       0.0011
TR                    1          0.167540      0.095478          1.7547       0.0954
-------------------------------------------------------------------------------------------

MODEL:     EG13                   SSE      4.592652        F RATIO            2.83
                                  DFE            19        APPROX PR>F      0.0837
DEP VAR: FPR                      MSE      0.241719        R-SQUARE         0.2298
                                  OBJ      6.019718

SECOND STAGE STATISTICS

                                 PARAMETER      STANDARD                      APPROX
VARIABLE             DF          ESTIMATE         ERROR          T RATIO     PROB>|T|

INTERCEPT             1          7.691511      2.567492          2.9957       0.0074
B001.QRP              1         -0.017253      0.016054         -1.0746       0.2960
QRPL                  1         -0.019620      0.010826         -1.8123       0.0858


MODEL:     EG15                   SSE     12.283325        F RATIO            2.59
DEP VAR: SPR                      DFE            20        PROB>F           0.1235
                                  MSE      0.614166        R-SQUARE         0.1145

                                 PARAMETER      STANDARD
VARIABLE             DF          ESTIMATE         ERROR          T RATIO     PROB>|T|

INTERCEPT             1          5.233622      0.402385         13.0065       0.0001
NC                    1          0.394113      0.245122          1.6078       0.1235
```

Table C.4--Continued

```
MODEL:    EC01
DEP VAR:  NPP

                                 PARAMETER          STANDARD                        APPROX
VARIABLE                 DF       ESTIMATE            ERROR          T RATIO      PROB>|T|

INTERCEPT                 1     352.702105         5.107390          69.0572        0.0001
B001.BARA1                1     -33.213006         1.938760         -17.1311        0.0001
B001.BARA2                1     -23.870040         4.955599          -4.8168        0.0002
CARA1                     1     -33.213006         1.938760         -17.1311        0.0001
CARA2                     1     -23.870040         4.955599          -4.8168        0.0002
------------------------------------------------------------------------------------------

MODEL:    EC02
DEP VAR:  CRF

                                 PARAMETER          STANDARD                        APPROX
VARIABLE                 DF       ESTIMATE            ERROR          T RATIO      PROB>|T|

INTERCEPT                 1      64.606847         0.312041         207.0458        0.0001
B001.BARB1                1       1.705401         0.134887          12.6432        0.0001
B001.BARB2                1    -0.00446157         0.210027          -0.0212        0.9833
CARB1                     1       1.705401         0.134887          12.6432        0.0001
CARB2                     1    -0.00446157         0.210027          -0.0212        0.9833
------------------------------------------------------------------------------------------

MODEL:    EC03
DEP VAR:  PCM

                                 PARAMETER          STANDARD                        APPROX
VARIABLE                 DF       ESTIMATE            ERROR          T RATIO      PROB>|T|

INTERCEPT                 1       5.840384         0.180204          32.4099        0.0001
B001.BARC1                1      -0.777007         0.064939         -11.9653        0.0001
B001.BARC2                1       0.477883         0.206360           2.3158        0.0333
CARC1                     1      -0.777007         0.064939         -11.9653        0.0001
CARC2                     1       0.477883         0.206360           2.3158        0.0333
------------------------------------------------------------------------------------------

MODEL:    EC04
DEP VAR:  ASR

                                 PARAMETER          STANDARD                        APPROX
VARIABLE                 DF       ESTIMATE            ERROR          T RATIO      PROB>|T|

INTERCEPT                 1       0.010004     0.0003893744          25.6928        0.0001
B001.BARD1                1   0.0008110735     0.0001610544           5.0360        0.0001
B001.BARD2                1   -0.000829343     0.0006786091          -1.2221        0.2383
CARD1                     1   0.0008110735     0.0001610544           5.0360        0.0001
CARD2                     1   -0.000829343     0.0006786091          -1.2221        0.2383
------------------------------------------------------------------------------------------

MODEL:    EC05
DEP VAR:  CCA

                                 PARAMETER          STANDARD                        APPROX
VARIABLE                 DF       ESTIMATE            ERROR          T RATIO      PROB>|T|

INTERCEPT                 1       0.089202      0.009250501           9.6429        0.0001
B001.BARE1                1       0.029678      0.004975088           5.9654        0.0001
B001.BARE2                1    -0.00373514         0.011205          -0.3333        0.7430
CARE1                     1       0.029678      0.004975088           5.9654        0.0001
CARE2                     1    -0.00373514         0.011205          -0.3333        0.7430
------------------------------------------------------------------------------------------

MODEL:    EQ06
DEP VAR:  UCA

                                 PARAMETER          STANDARD                        APPROX
VARIABLE                 DF       ESTIMATE            ERROR          T RATIO      PROB>|T|

INTERCEPT                 1       0.589437       0.00970507          60.7349        0.0001
B001.BARF1                1      -0.041487      0.005395524          -7.6892        0.0001
B001.BARF2                1      -0.038089         0.017892          -2.1289        0.0482

CARF1                     1      -0.041487      0.005395524          -7.6892        0.0001
CARF2                     1      -0.038089         0.017892          -2.1289        0.0482
```

Table C.4--Continued

```
-----------------------------------------------------------------------------

MODEL:    EC07
DEP VAR: CRF

                           PARAMETER       STANDARD                         APPROX
VARIABLE          DF        ESTIMATE          ERROR        T RATIO        PROB>|T|

INTERCEPT          1     -651.684451     491.071332        -1.3275          0.2030
RS                 1       -0.138090       0.171024        -0.8074          0.4313
TR                 1        0.316406       0.249653         1.2673          0.2222
PS                 1      -20.029063       7.347757        -2.7259          0.0150
RRPL               1       20.951010       2.724008         7.6912          0.0001
GRPL               1        1.000000   2.18415E-05     99999.0000          0.0001
-----------------------------------------------------------------------------

MODEL:    EC08
DEP VAR: UZF

                           PARAMETER       STANDARD                         APPROX
VARIABLE          DF        ESTIMATE          ERROR        T RATIO        PROB>|T|

INTERCEPT          1       62.766980       0.644698        97.3586          0.0001
8001.BARG1         1       -4.685466       0.212718       -22.0266          0.0001
8001.BARG2         1     -0.00507448       0.397431        -0.0128          0.9900
8001.BARG3         1        2.195378       0.807355         2.7192          0.0158
CARG1              1       -4.685466       0.212718       -22.0266          0.0001
CARG2              1     -0.00507448       0.397431        -0.0128          0.9900
CARG3              1        2.195378       0.807355         2.7192          0.0158
-----------------------------------------------------------------------------

MODEL:    EC09
DEP VAR: UZP

                           PARAMETER       STANDARD                         APPROX
VARIABLE          DF        ESTIMATE          ERROR        T RATIO        PROB>|T|

INTERCEPT          1       59.938012       1.036665        57.8070          0.0001
8001.BARH1         1        5.431729       0.325554        16.6846          0.0001
8001.BARH2         1        0.756411       0.746745         1.0129          0.3271
8001.BARH3         1       -1.746237       0.828289        -2.1082          0.0522
CARH1              1        5.431729       0.325554        16.6846          0.0001
CARH2              1        0.756411       0.746745         1.0129          0.3271
CARH3              1       -1.746237       0.828289        -2.1082          0.0522
-----------------------------------------------------------------------------

MODEL:    EC11
DEP VAR: RFP

                           PARAMETER       STANDARD                         APPROX
VARIABLE          DF        ESTIMATE          ERROR        T RATIO        PROB>|T|

INTERCEPT          1     -266.497752     175.282224        -1.5266          0.1433
8001.WPP           1        1.606135       0.423423         3.7932          0.0012
TR                 1        0.135395       0.087609         1.5455          0.1387
-----------------------------------------------------------------------------

MODEL:    EC13
DEP VAR: FFF

                           PARAMETER       STANDARD                         APPROX
VARIABLE          DF        ESTIMATE          ERROR        T RATIO        PROB>|T|

INTERCEPT          1        7.401588       1.267165         5.8411          0.0001
8001.QRP           1       -0.018821     0.00854402        -2.2028          0.0402
QRPL               1       -0.016112    0.005588908        -2.8828          0.0095
-----------------------------------------------------------------------------

MODEL:    EC15
DEP VAR: SFR


                           PARAMETER       STANDARD                         APPROX
VARIABLE          DF        ESTIMATE          ERROR        T RATIO        PROB>|T|

INTERCEPT          1        5.299291       0.375774        14.1023          0.0001
MC                 1        0.350139       0.225387         1.5535          0.1360
```

Table C.5--Demand Elasticities

Elasticity of	With Respect to							
	Retail Price of Fresh	Retail Price of Processed	All Away-From-Home Food Consumption	Fast Food Consumption	Women in the Labor Force	Income	Population	Advertising
Fresh/UZF	-.0452	.3419	-.0892	-.0698	-.2444	-.2434	-.3644	-
Processed/UZP	-.0269	.4376	.0661	.0587	.1666	.2692	.3181	.1789

Table C.6--Long and Short Term Multipliers

```
FOR INTERIM     1

                                                        INTERIM MULTIPLIERS

                MS           CT           GD           CK           PS           MC           TR           RS           GC           IF           FF
NPP      -0.054975   -0.0920116       9.5134     -0.15607      1.35373    0.0434156     0.229511   0.00904294     -12.5571   -.00012122     -0.33691
CRP     0.00638431    0.0105150     -1.65728    0.0176592   -0.0624057   -.00062717   -.00695736   -.00041134     0.447891   .000004197     0.314502
PCM     -.00464702   -.00782360     0.600253   -0.0133186    0.0138272   .000181212   0.00141283  [illegible]  [illegible]   -0.430E-07   -0.0637267
ASR      5.220E-05    8.764E-06   -.00078197   .000014893   -.00010804   -1.649E-07   -3.613E-07  [illegible]  [illegible]    1.062E-09   .030979679
CCA     -9.522E-03   -.00016048    0.0115366   -.00027337   .000734859   .000013176   0.00007063  [illegible]  [illegible]   -4.015E-09   -.00108051
UCA     .000107221   .000179783   -0.0171263   .000305285   -0.0025992   -.00002367   -.00011494   -1.724E-05   0.00795361    7.625E-08   0.00583694
ORP              0            0            0            0     -12.5131            0     0.105738   -0.0829749            0            0            0
UZF     -0.0155251   -0.0261321      2.03109   -0.0444799       1.5971   0.00060825   -0.0180492    0.0105241    -0.304162   -2.075E-06    -0.217245
UZP       0.031425    0.0510547     -8.75008    0.0871737      -2.4853   -.00174426   0.00714659   -0.0164801      1.76208   .000016412      1.22276
RPF              0            0            0            0     0.517721            0   -.00768478   0.00343303            0            0            0
RPP     -.00802827   -0.0135163      1.03701   -0.0230095     0.919311   .000313065   -0.0108355   0.00608935    -0.153999   -1.456E-06    -0.110095
WPP     -.00464702   -.00782360     0.600253   -0.0133186     0.531548   .000181212   -.00627196   0.00352471   -0.0891399   -8.430E-07   -0.0637267
FPR              0            0            0            0     0.517721            0   -.00768478   0.00343303            0            0            0
RPT     .000159027   .000257226   -0.0671899   .000426939   -.00898201   -.00001136   -.00010903   -.00005956    0.0145792    1.354E-07    0.0100552
SPR              0            0            0            0            0            0            0            0            0            0            0
UZO     -0.0159027   -0.0257226      6.71899   -0.0426939     -11.6149   0.00113601     0.196641   -0.0770189     -1.45792   -1.354E-05     -1.30552

                PN           IN           WN           GR     INTERCEP
NPP     -0.0617726   -.00373487     -18.1953   -0.0239499     -426.292
CRP     0.00206516   .000119098     0.543243   0.00517613      14.6117
PCM     -.00041947   -2.457E-05    -0.128371   -.00137552     -1.29317
ASR      5.233E-07    3.022E-08   .000162747    1.888E-06   -.00024173
CCA     -2.036E-05   -1.223E-06   -.00604492   -2.576E-05    -0.103394
UCA     .000038552   .000002307    0.0115009   .000042165      0.20154
ORP              0            0            0            0     -234.258
UZF     -.00142979   -8.367E-05    -0.437964   -0.0046773      34.3243
UZP     0.00801627   .000457472      2.52612    0.0242306    -0.519336
RPF              0            0            0            0      13.0783
RPP     -.00072469   -4.244E-05    -0.221776   -.00237637      20.3602
WPP     -.00041947   -2.457E-05    -0.128371   -.00137592      11.7651
FPR              0            0            0            0      13.0783
RPT     .000065865   .000003738    0.0208815   .000195533      0.33805
SPR              0            0            0            0            0




UZO     -.00658640   -0.0003738     -2.00815   -0.0195533     -268.063

FOR INTERIM     2

                                                        INTERIM MULTIPLIERS

                MS           CT           GD           CK           PS           MC           TR           RS           GE           TF           FF
NPP     -0.0373512   -0.0622503      7.63656    -0.105312      1.66093   0.00175805   -.00042414    0.0110137     -1.40912   -1.317E-05    -0.985154
CRP     0.00438745   0.00737471    -0.619822    0.0125419   -0.0626172   -.00016244   -.00073281   -.00341522    0.0934207    8.793E-07    0.0602346
PCM     -.00275604   -0.0046382     0.364113   -.00789393    0.0161169   0.00010693   .000745198   .000106871   -0.0544099   -5.148E-07    -0.038078
ASR      3.152E-05    5.305E-06   -.00041556    9.028E-06   -5.483E-05   -1.208E-07   -3.013E-07   -3.636E-07   .000061746    5.833E-10   .000344049
CCA     -5.683E-05   -9.551E-05   0.00810807   -.00016242   .000716771    2.290E-06   .000312164    4.753E-06   -.00127675   -1.203E-08  -.000390661
UCA     .000067013   .000112483   -0.0101618   .000191131   -.00175952   -2.724E-06   -2.950E-06   -1.167E-05   0.00164272    1.545E-08   0.00116201
ORP              0            0            0            0     -1.52515            0    0.0226385   -0.0101133            0            0            0
UZF     -.00922193   -0.0155198      1.21894   -0.0264135     0.650398   .000357552   -.00635943   0.00431275    -0.182389   -1.723E-06    -0.130125
UZP      0.0212702    0.0357729     -2.91515    0.0600579     -1.11348   -.00078015   0.00881509   -.00738352     0.431409    4.057E-06     0.306469
RPE              0            0            0            0     0.200284            0   -.00297292   0.00132309            0            0            0
RPP     -.00476137   -.00801302     0.629037   -0.0136377     0.373858   .000104734   -.00381955   0.00247906   -0.0941376   -8.894E-07   -0.0671662
WPP     -.00275604   -0.0046382     0.364113   -.00789393     0.216401   0.00010693   -.00222773   0.00143496   -0.0544899   -5.148E-07    -0.039878
FPR              0            0            0            0     0.200284            0   -.00297292   0.00132809            0            0            0
RPT     .000120482   .000202527   -0.0169622   .000344444   -.00463091   -4.226E-06   .000024557   -3.071E-05    0.0024902    2.344E-08   0.00176345
SPR              0            0            0            0            0            0            0            0            0            0            0
UZO     -0.0120482   -0.0202527      1.69622   -0.0344444     -1.06206   .000422593    0.0201829   -.00704255     -0.24902   -2.344E-06    -0.176345

                PN           IN           WN           GR     INTERCEP
NPP     -.00646513   -.00037141     -2.02239   -0.0200051     -3.27062
CRP     .000435492   .000025326     0.134365   0.00146767     0.552433
PCM     -.00025584   -1.496E-05   -0.0784475   -.00084162    -0.676414
ASR      2.899E-07    1.695E-08   .000088892    9.598E-07   .000304895
CCA     -5.962E-05   -3.472E-07   -.00183675   -1.926E-05   -0.0121917
UCA      7.638E-05    4.433E-07   0.00236195   .000024628   0.00501326
ORP              0            0            0            0       43.312
UZF     -.00005629   -5.006E-05    -0.262577   -.00281799      4.91619
UZP     0.00201557   .000117413     0.620672   0.00602969      -7.3860
RPF              0            0            0            0      2.40951
RPP     -.00044199   -2.584E-05    -0.135527    -0.001454      2.99412
WPP     -.00025584   -1.496E-05   -0.0784475   -.00084162      1.73309
FPR              0            0            0            0      2.40951
RPT     .000011593    6.735E-07   0.00358095   .000040117   -0.0247061
SPR              0            0            0            0            0
UZO     -.00115925   -6.735E-09    -0.358095   -0.0040117      45.7026
```

Table C.6--Continued

```
                                                             INTERIM MULTIPLIERS

               MS          CT          GD          CK          PS          MC          TS          RS          GC          TF          FF
NPP    -0.0237785  -0.0399195     3.19732  -0.0679258    0.717737  .000893525  -.00211127  0.00475934    -0.47552  -4.407E-06   -0.338482
CRP    0.00263067  0.00442717   -0.147932  0.00753471  -0.0289106  -.00010144  -.00053946  -.00019104   0.0519989   4.903E-07   0.0370211
PCM    -.00163897  -.00275925    0.216521  -.00469434   0.0112866   0.0000635  .000417705  .000074847  -0.0323098  -3.061E-07  -0.0231153
ASF     1.874E-05   3.153E-06  -.00024755   5.307E-06  -.00000775  -7.259E-08  -5.537E-07  -5.139E-08 .0000037018   3.497E-10 .0000026411
CCA    -3.414E-05  -5.745E-05  0.00452636  -9.776E-05  .000342237  .000001317   7.129E-06   2.269E-06  -.00006755  -6.390E-09  -.00040247
UCA   .0000040504 .0000060242  -.00539191  .000116222  -.00045019  -1.560E-06  -7.717E-06  -3.038E-06  .000804960   7.602E-09  .000573934
ORP             0           0           0           0     2.72563           0  -0.0404579   0.0180737           0           0           0
UZF    -.00548445  -.00922937    0.724869  -0.0157086   -0.359927  .000212491  0.00271424  -0.0003377   -0.190415  -1.024E-06  -0.0773476
UZP     0.0127033   0.0213708    -1.67767   0.0363056  0.00817414  -.00049071  -.00464498 .003054203    0.250447   2.366E-06    0.178676
RPF             0           0           0           0  -0.0298784           0  .000443499  -.00019812           0           0           0
RPP    -.00283151  -.00476518    0.374238  -.00811001  -0.0321195  .000109703  0.00148783  -.00021299  -0.0559743  -5.208E-07  -0.0399343
WPP    -.00163897  -.00275025    0.215521  -.00469434  -0.0105918   0.0000635  .000861204  -.00012328  -0.0323958  -3.061E-07  -0.0231153
FPR             0           0           0           0  -0.0298784           0  .000443499  -.00019812           0           0           0
RPT    .000072183  0.00012149  -.00952799  0.00020677  -.00042753  -2.702E-06  -1.931E-05  -2.835E-06  0.00142032   1.342E-08  0.00101328
SPR             0           0           0           0           0           0           0           0           0           0           0
UZO    -.00721083   -0.012149    0.952799   -0.020677     2.76038  .000273225  -0.0385271   0.0183572   -0.142032  -1.342E-06   -0.101328

               PN          IN          WN          GR    INTERCEP
NPP    -0.0022267  -.00012993   -0.598345  -.00744476    0.478135
CRP    .000243612  .000014241   0.0747148  .000804141    0.595995
PCM    -.00015211  -8.893E-06  -0.0466445  -.00050078    -0.40687
ASF     1.738E-07   1.015E-09  .000053293   5.722E-07  .000883904
CCA    -3.175E-06  -1.856E-07  -.00097308  -1.048E-05  -.00802353
UCA     3.776E-05   2.207E-07  0.00115876  .000012489   0.0145337
ORF             0           0           0           0     94.4537
UZF    -.00050899  -2.976E-05    -0.15608  -.00167574    -8.36891
UZP    0.00117577  .000060741    0.360556  0.00387727     13.1672
RPF             0           0           0           0    -2.35599
RPP    -.00026279  -1.536E-05  -0.0805837  -.00086516    -4.77316
WPP    -.00015211  -8.893E-06  -0.0466445  -.00050078    -2.76286
FPR             0           0           0           0    -2.35599




RPT     6.660E-05   3.898E-07  0.00204476  .000022015   0.0479825
SPR             0           0           0           0           0
UZO    -.00366679  -3.890E-05   -0.204476  -.00220153     89.6524

FOR INTERIM      4

                                                             INTERIM MULTIPLIERS

               MS          CT          GD          CK          PS          MC          TR          RS          GC          TF          FF
NPP    -0.0141432   -0.023002      1.8695  -0.0405096  -.00219354  .000547089  0.00507533  -1.455E-05   -0.279192  -2.639E-06   -0.199178
CRP    0.00156451  0.00263294   -0.206743  0.00449109  -.00447339  -6.061E-05  -.00049208  -2.966E-05   0.0309177   2.921E-07   0.0223581
PCM    -.00097471  -.00164036    0.128922  -.00279177  0.00543891  .000037762  0.00026729  .000036066   -0.019267  -1.820E-07  -0.0137459
ASF     1.114E-05   1.875E-06  -.00014727   3.192E-06   7.507E-06  -4.317E-09  -5.093E-07   4.979E-08  .000022026   2.331E-10  .000015714
CCA    -2.031E-05  -3.419E-05  0.00268396  -5.817E-05  .000367017   7.866E-07  .000036255   4.444E-07  -.00040136  -3.792E-09  -.00029634
UCA    0.00002415 .0000340642  -.00319136  0.00306917  .000153785  -9.352E-07  -1.990E-05   1.020E-06  .000477176   4.508E-09  .000340436
ORP             0           0           0           0      2.0915           0  -0.0310452   0.0138699           0           0           0
UZF    -.00326165  -.00548709    0.431375  -.00934205   -0.209244  .000126363  0.00327049  -0.0013875  -0.0644728  -6.091E-07  -0.0459975
UZP    0.00755342   0.0127126   -0.998246    0.021636    0.303921  -.00029266  -.00720652  0.00201465    0.149293   1.410E-06    0.106513
RPF             0           0           0           0   -0.076431           0   0.0011345  -.00050592           0           0           0
RPP    -.00169393  -0.0028337    0.222555  -.00482311   -0.122647  .000065239  0.00242176  -.00081328   -0.033286  -3.145E-07  -0.0237476
WPP    -.00097471  -.00164036    0.128922  -.00279177  -0.0709921  .000037762  0.00140179  -.00047075   -0.019267  -1.820E-07  -0.0137459
FPR             0           0           0           0   -0.076431           0   0.0011345  -.00050602           0           0           0
RPT   .0000342923 .0000722315  -.00367171  0.00012294  .000945776  -1.663E-06  -.00032936   6.271E-06  .000848705   8.014E-09  .000535154
SPR             0           0           0           0           0           0           0           0           0           0           0
UZO    -.00429227  -.00722354    0.367171   -0.012294     1.97692  .000166293  -0.0291091   0.0132417  -0.0848705  -8.014E-07  -0.0535154

               PN          IN          WN          GR    INTERCEP
NPP    -.00131068  -.00007663   -0.401925  -.00431988    -10.7073
CRP    .000145153   6.487E-06   0.0445108  .000477914    0.677495
PCM    -9.045E-05  -5.299E-06  -0.0277379  -.00029761   -0.293149
ASF     1.334E-07   6.040E-09  0.00003171   3.434E-07  .003718400
CCA    -1.854E-05  -1.102E-07  -.00057782  -6.205E-06  -0.0062931
UCA     2.240E-05   1.310E-07  .000686069   7.377E-06   0.0173769
ORF             0           0           0           0     44.4477
UZF    -.00330269  -1.770E-05  -0.0375105  -.00394054    -7.30991
UZP    .000700507 .0000409879 [illegible]  0.00870706     12.1788
RPF             0           0           0           0    -2.12591
RPP    -.00015677 [illegible]  -0.0477204  -.00051443     -4.1792
WPP    -9.045E-05 [illegible]  -0.0277379 [illegible]    -2.41595
FPR             0           0           0           0    -2.12591
[illegible]
```

Table C.6--Continued

TOTAL MULTIPLIERS

	MS	CT	GD	CK	PS	MC	TR	RS	GC	TF	FF
NPP	-1.56049	-4.20239	418.605	-1.04266	3.74838	0.0559869	0.288035	0.0248556	-17.5714	-.00016897	-12.9695
CRP	0.0886501	0.130871	-7.63429	0.203646	-0.181632	-.00129536	-0.0143294	-.00120441	0.985513	9.223E-06	0.690311
PCM	-0.0195022	-0.0328769	2.32739	-0.056013	0.05661	.000597027	0.00441533	.000375382	-0.288876	-2.733E-06	-0.206716
ASR	.000018045	.000029461	-.00641696	.000049194	-.00024024	-1.156E-06	-1.910E-05	-1.593E-06	0.00135618	1.261E-08	0.00093735
CCA	-.00061403	-.00145254	0.136295	-.00534416	0.00217945	.000030357	.000168051	.000014452	-0.0104244	-9.985E-00	-.00763679
UCA	0.00099505	0.00244588	-0.240581	0.00496635	-.00601967	-8.914E-05	-.00046277	-3.992E-05	0.0282915	2.719E-07	0.0208618
QRP	0	0	0	0	-30.1337	0	0.44729	-0.199818	0	0	0
UZF	-0.065107	-0.109745	7.82707	-0.186961	3.09361	-0.122907	0.282143	0.0205138	-30.4964	-0.000263	-18.0836
UZP	0.123259	0.205439	-25.1458	0.347564	-4.96726	-0.075461	-0.381363	-0.0329381	23.1652	.000222987	17.1315
RPF	0	0	0	0	0.975724	0.355142	-0.0144831	0.00647006	0	0	0
RPP	-0.0336923	-0.0567987	4.02082	-0.0967689	1.78348	0.00103143	0.143773	0.0118263	-0.499067	-4.722E-06	-0.357126
WPP	-0.0195022	-0.0328769	2.32739	-0.056013	1.03233	.000597027	-0.0100678	0.00684544	-0.288876	-2.733E-06	-0.206716
FPR	0	0	0	0	0.975724	0	-0.0144831	0.00647006	0	0	0
RPT	.000581523	.000956943	-0.173187	0.00160603	-0.0187365	-.00198368	-0.0009922	-.00012424	-0.073312	-4.001E-07	-.00952159
SPR	0	0	0	0	0	0.355142	0	0	0	0	0
UZU	-0.0581523	-0.0956943	17.3187	-0.160603	-28.2601	0.198368	0.54651	-0.187394	7.3312	.000040013	0.952159

	PV	IN	WN	GR	INTERCEP
NPP	-0.0857252	-.00515326	-25.4313	-0.805094	-307.415
CRP	0.00453137	0.00026076	1.41493	0.0182111	88.7189
PCM	-.00136084	-7.976E-05	-0.416075	-.00516256	-2.15604
ASR	6.142E-05	3.492E-07	0.00194305	.000018345	0.0458278
CCA	-5.043E-05	-3.013E-06	-0.0150595	-.00027094	-0.218396
UCA	.000137874	8.282E-06	0.0409403	.000480829	1.46197
QRP	0	0	0	0	-706.12
UZF	-0.115781	-.00557163	-42.7641	-0.017417	-410.002
UZP	0.113263	0.00681907	33.5375	0.065842	743.069
RPF	0	0	0	0	35.1755
RPP	-0.002351	-0.0001378	-0.718817	-.00891891	-272.351
WPP	-.00136084	-7.976E-05	-0.416075	-.00516256	27.7276
FPR	0	0	0	0	29.8836
RPT	-2.518E-05	.000012474	-0.0922653	0.00048425	3.33067
SPR	0	0	0	0	5.29182
UZU	0.00251849	-.00124745	9.22653	-0.048425	-1039.19

Table C.7--Root Mean Square Errors

```
                 STATISTICS OF FIT

VARIABLE       RMS ERROR     RMS % ERROR

NPP              19.7544         5.59593
CRP              1.28542         2.12646
PCM             0.803821         13.7753
ASF           0.00127036         16.5902
CCA            0.0413663          67.563
UCA            0.0422307         7.39759
QRP              7.03018         4.71475
UZF              4.19141         7.36534
UZP              4.12542         7.75064
RPF             0.877485         9.83404
RPP              1.02812         10.0341
WPP             0.462496         5.87559
FPR             0.542427         24.6539
RPT             0.920214         9.32744
SPR             0.747689         12.2835
UZD              6.20647         23.4467
```

TABLE C.8--RAW DATA FOR ANALYSIS OF POTATO SUBSECTOR

YEAR	NPP	CFF	FCM	ASR	CCA	UCA	GRP	UZF	LZP	RPF
1957	.	.	.	.	.	.	142.217	91.0372	23.9860	.
1958	.	.	.	.0038484	.	.	140.150	89.2779	28.3762	.
1959	451	.	9.10685	.0050010	.	.	141.251	86.8448	26.8976	.
1960	446	55.7355	8.51633	.0043740	0.214660	0.475000	142.282	85.3968	32.7338	8.1591
1961	426	56.4342	9.49942	.0045505	0.232759	0.404895	159.590	86.2056	39.5024	7.0595
1962	442	59.7422	8.38533	.0065808	0.118881	0.475625	141.913	82.3499	35.3574	7.0300
1963	456	61.0061	7.71153	.0082772	0.084375	0.496564	143.318	79.4826	39.1142	7.1382
1964	480	63.4143	5.44798	.0087419	0.092219	0.589885	125.626	68.9427	36.1798	8.1926
1965	456	63.6884	6.42295	.0089970	0.172559	0.548393	149.871	73.1858	51.5697	9.9258
1966	436	63.8889	5.85751	.0094326	0.211521	0.542211	156.104	69.3266	54.1709	7.5580
1967	417	62.3049	6.17633	.0097592	0.117013	0.471971	153.699	67.4383	53.5984	7.4700
1968	405	63.0667	5.76670	.0111302	0.079814	0.534664	146.487	63.3284	56.1535	7.3649
1969	387	63.2260	6.26574	.0107438	0.075454	0.587281	153.873	64.9235	60.3848	7.4931
1970	365	63.3372	6.36068	.0100519	0.095934	0.628260	158.826	63.9746	66.5890	7.8068
1971	353	64.4142	6.28582	.0104708	0.062712	0.630715	153.757	58.5648	66.5912	7.2720
1972	336	65.3510	5.05001	.0129395	0.068847	0.621313	140.998	53.5650	63.8804	7.4980
1973	315	65.4669	3.42003	.0121186	0.047159	0.591185	141.298	50.9707	67.8358	9.6818
1974	297	66.4586	4.49404	.0097325	0.037346	0.632122	159.916	59.0439	72.0697	10.2907
1975	280	66.4664	4.00042	.0133198	0.039178	0.611572	148.071	52.4963	71.1167	7.6625
1976	269	67.6602	4.49052	.0122228	0.031588	0.659288	164.071	56.4789	80.1592	8.0752
1977	261	68.1186	5.07429	.0121615	0.060648	0.675164	161.025	52.9301	78.0663	7.7888
1978	249	69.1903	5.14562	.0147668	0.028869	0.696997	164.562	50.3576	78.2902	8.0038
1979	235	70.0255	5.30764	.0108221	0.027154	0.738134	152.153	51.0693	73.7912	7.7569
1980	227	70.7780	3.93126	.0074265	0.045823	0.649335	133.007	42.6992	67.1423	7.5059
1981	221	71.6413	4.87909	.0114710	0.017695	0.705467	147.278	48.1248	74.7134	9.0896
1982	.	.	.	.	0.016559	.	.	.	.	7.3784

TABLE C.8--CONTINUED

YEAR	RPF	WFF	SPR	FPR	RPT	UZC	MS	PCNL	CT	GC
1957	.	.	.	2.04716	0.000	27.1936	.	.	.	.
1958	.	.	.	1.38478	0.000	22.4963	.	.	.	.
1959	.	11.5014	.	2.39451	0.000	27.5090	.	.	.	.
1960	14.1119	10.6238	6.05161	2.10748	0.000	24.1516	5.0	9.10685	17.1251	0.829809
1961	14.2852	10.9386	5.62033	1.43915	0.000	33.8775	5.0	8.51633	17.1054	0.822844
1962	13.8854	10.1469	5.26843	1.76160	0.000	24.2058	7.5	9.49942	17.1413	0.822323
1963	13.4257	9.5951	5.25456	1.88360	0.000	24.7215	7.5	8.38533	17.2192	0.819365
1964	12.4137	9.1439	4.49676	3.69588	0.000	20.5034	10.0	7.71153	16.9429	0.818045
1965	12.5786	9.0420	7.30680	2.61905	0.000	25.1158	15.0	5.44798	16.6032	0.812730
1966	11.2871	7.9016	5.51393	2.04409	0.000	32.6043	15.0	6.42295	16.3580	0.802221
1967	10.8053	8.0463	5.60000	1.87000	0.000	32.6623	17.5	5.85751	16.3900	0.804876
1968	10.6280	7.9423	5.18926	2.17561	0.000	27.0055	20.0	6.17633	16.0653	0.806085
1969	10.5878	8.3690	5.38983	2.10329	0.000	28.5644	20.0	5.76670	15.7286	0.791227
1970	10.3031	8.3625	5.80498	2.00181	0.000	28.2623	25.0	6.26574	15.4944	0.782671
1971	9.9475	7.9525	5.60529	1.66667	0.000	28.6013	25.0	6.36068	15.6966	0.780569
1972	9.6996	7.5773	4.97069	2.52729	0.000	23.5526	27.5	6.28582	15.3631	0.763684
1973	8.8261	7.0503	6.05146	3.63029	1.188	22.4913	27.5	5.05001	16.8820	0.751778
1974	9.7332	6.9987	7.78598	2.50468	1.311	28.8022	27.5	3.42003	24.2180	0.767486
1975	10.1622	6.5619	5.10102	2.56146	1.236	24.4583	30.0	4.49404	24.1998	0.729739
1976	10.4058	6.4577	6.10801	1.96721	1.366	27.4326	32.5	4.00042	24.6041	0.718237
1977	10.6182	6.9023	5.96075	1.82801	1.310	30.0282	35.0	4.49052	26.1207	0.733862
1978	10.4730	6.7605	6.38888	1.61491	1.286	30.5049	35.0	5.07429	25.9980	0.713417
1979	11.0008	6.7635	6.30107	1.45586	1.249	27.0746	40.0	5.14562	33.5051	0.733941
1980	9.8193	6.3680	5.06914	2.43676	1.098	23.1656	40.0	5.30764	40.0365	0.723949
1981	10.6010	6.7196	7.24909	1.84049	1.228	24.4393	45.0	3.93126	39.0602	0.729301
1982	.	.	5.84530	1.53307	.	.	50.0	4.87909	34.7631	.

TABLE C.8--CONTINUED

YEAR	MC	TR	RS	GC	TF	FF	PN	IN	WN
1957	.	1957	.	0.628292	.	.	172.0	2127.64	0.312137
1958	.	1958	.	0.628369	13238.4	0.084638	174.9	2104.80	0.315176
1959	.	1959	.	0.627820	13819.8	0.102290	177.8	2173.05	0.317480
1960	0.872	1960	17.5052	0.622801	14372.3	0.112659	180.7	2183.67	0.322586
1961	0.880	1961	15.8912	0.628205	14950.8	0.122679	183.7	2213.31	0.326409
1962	0.897	1962	22.1226	0.629341	15432.2	0.132332	186.6	2279.08	0.327428
1963	0.915	1963	14.9236	0.620418	15944.0	0.151304	189.2	2332.04	0.331711
1964	0.915	1964	30.5858	0.631068	16969.8	0.155376	191.9	2457.44	0.335527
1965	0.940	1965	38.5302	0.645617	17881.4	0.168266	194.3	2577.15	0.339890
1966	0.974	1966	12.4348	0.670065	18318.8	0.180300	196.6	2678.77	0.346457
1967	1.000	1967	14.3032	0.668297	18589.2	0.190328	198.7	2749.37	0.351454
1968	1.035	1968	22.9889	0.662649	19887.1	0.211797	200.7	2826.00	0.355431
1969	1.092	1969	14.0039	0.662202	20277.1	0.224977	202.7	2850.41	0.362666
1970	1.161	1970	15.2668	0.682262	21102.0	0.243271	205.1	2899.83	0.367391
1971	1.230	1971	11.2261	0.668812	21396.0	0.253484	207.7	2984.44	0.369635
1972	1.305	1972	25.0200	0.676696	22709.7	0.303406	209.9	3080.55	0.374420
1973	1.394	1973	32.2020	0.666254	24032.8	0.288094	211.9	3241.75	0.379624
1974	1.598	1974	28.9123	0.700071	23906.2	0.303889	213.9	3159.87	0.384942
1975	1.788	1975	26.9880	0.721151	25344.0	0.322792	216.0	3148.26	0.391242
1976	1.936	1976	20.0029	0.722242	26876.7	0.337425	218.0	3213.43	0.397453
1977	2.092	1977	18.1849	0.683890	27749.3	0.376352	220.2	3287.77	0.402546
1978	2.270	1978	30.0160	0.734439	29067.7	0.360427	222.6	3388.81	0.409628
1979	2.522	1979	8.4300	0.737957	29972.8	0.355109	225.1	3372.11	0.414597
1980	2.860	1980	31.9176	0.742751	29810.9	0.371297	227.7	3245.94	0.425351
1981	3.178	1981	27.7273	0.750131	29909.7	0.372869	229.9	3240.09	0.429705
1982	3.340	1982	.	.	31280.3	0.377343	232.1	3239.04	0.433329

TABLE C.8 CONTINUED

YEAR	CK	FS	CRFL	FFRL	GR	UZPL	ASRL
1957	.	.	.	.	.	.	.
1958	.	0.60129	142.217	2.04716	.	23.9860	.
1959	.	0.62051	140.150	1.38478	.	28.3762	0.0038484
1960	4.82	0.59283	141.251	2.39451	26.4200	26.8976	0.0050010
1961	4.50	0.61012	142.282	2.10748	29.3359	32.7338	0.0043740
1962	4.50	0.59048	159.590	1.43915	33.0446	39.5024	0.0045505
1963	4.50	0.67194	141.913	1.76160	35.8646	35.3574	0.0065808
1964	4.50	0.64656	143.318	1.88360	37.9914	39.1142	0.0082772
1965	4.54	0.62249	125.626	3.69588	36.8838	36.1798	0.0087419
1966	5.63	0.61853	149.871	2.61905	42.2879	51.5697	0.0089970
1967	5.61	0.64128	156.104	2.04409	47.3068	54.1709	0.0094326
1968	6.30	0.67750	153.699	1.67000	53.1130	53.5984	0.0097592
1969	7.96	0.67366	146.487	2.17561	54.6409	56.1535	0.0111302
1970	7.91	0.59624	153.873	2.10329	56.7122	60.3848	0.0107438
1971	5.72	0.67029	158.826	2.00181	61.0424	66.5890	0.0100519
1972	5.25	0.67544	153.757	1.66667	64.5217	66.5912	0.0104708
1973	8.03	0.67170	140.998	2.52729	65.6869	63.8804	0.0129395
1974	10.81	1.09874	141.298	3.63029	66.1025	67.8358	0.0121186
1975	7.86	1.46159	159.916	2.50466	67.9286	72.0697	0.0097325
1976	6.84	0.78902	148.071	2.56146	70.3407	71.1167	0.0133198
1977	6.83	0.57377	164.071	1.96721	74.4485	80.1592	0.0122228
1978	9.06	0.62307	161.025	1.82801	76.4474	78.0663	0.0121615
1979	12.67	0.60201	164.562	1.61491	78.8386	78.2902	0.0147668
1980	15.27	0.71944	152.153	1.45566	76.7159	73.7912	0.0108221
1981	18.87	0.87798	133.007	2.43676	73.0746	67.1423	0.0074265
1982	14.86	0.49761	147.278	1.84049	71.8823	74.7134	0.0114710

Table C.9--Simulated Effects of Specific Policy Variables

```
                              POLICY ANALSIS FOR POTATOES
                           --- EXOGENOUS VARIABLE = FF ---
                           MEAN CHANGE OF FF IS 4.6 PERCENT

OBS   NPPHAT    CRPHAT    PCMHAT     ASRHAT      CCAHAT      JCAHAT    QRPHAT   UZFHAT

  1   199.861   71.5122   3.89918    0.0119681   -0.023673   0.733153  137.425  47.0344
  2   199.829   71.5160   3.89837    0.0119812   -0.023716   0.733367  137.425  46.7782
  3   199.799   71.5197   3.89757    0.0119940   -0.023757   0.733577  137.425  46.4681
  4   199.769   71.5234   3.89678    0.0120066   -0.023798   0.733783  137.425  46.1639
  5   199.739   71.5269   3.89602    0.0120189   -0.023838   0.733984  137.425  45.8552
  6   199.710   71.5305   3.89526    0.0120310   -0.023877   0.734182  137.425  45.5718
  7   199.682   71.5339   3.89452    0.0120429   -0.023915   0.734377  137.425  45.2834
  8   199.654   71.5373   3.89380    0.0120546   -0.023953   0.734567  137.425  44.9999
  9   199.627   71.5407   3.89308    0.0120660   -0.023990   0.734755  137.425  44.7209
 10   199.600   71.5440   3.89238    0.0120773   -0.024026   0.734940  137.425  44.4463

OBS   UZPHAT    RPFHAT    RPPHAT     WPPHAT      FPRHAT      RPTHAT    SPRHAT   UZCHAT

  1   74.9680   9.05098   10.2981    6.52970     2.63052     1.22062   6.42046  15.3634
  2   75.2288   9.05098   10.2967    6.52889     2.63052     1.22007   6.42046  15.4179
  3   75.4842   9.05098   10.2953    6.52809     2.63052     1.21952   6.42046  15.4726
  4   75.7345   9.05098   10.2939    6.52731     2.63052     1.21898   6.42046  15.5264
  5   75.9801   9.05098   10.2926    6.52654     2.63052     1.21845   6.42046  15.5796
  6   76.2211   9.05098   10.2913    6.52579     2.63052     1.21793   6.42046  15.6319
  7   76.4578   9.05098   10.2900    6.52505     2.63052     1.21741   6.42046  15.6836
  8   76.6903   9.05098   10.2888    6.52432     2.63052     1.21690   6.42046  15.7347
  9   76.9188   9.05098   10.2875    6.52360     2.63052     1.21640   6.42046  15.7851
 10   77.1435   9.05098   10.2863    6.52290     2.63052     1.21590   6.42046  15.8349
```

Table C.9--Continued

```
                              POLICY ANALSIS FOR POTATOES
                             --- EXOGENOUS VARIABLE = TF ---
                             MEAN CHANGE OF TF IS 1.1 PERCENT

OBS    NPPHAT     CRPHAT     PCMHAT     ASRHAT       CCAHAT       UCAHAT     QRPHAT     UZFHAT

  1    199.860    71.5122    3.89918    0.0119681    -0.023673    0.733153   137.425    47.0942
  2    199.860    71.5122    3.89917    0.0119683    -0.023674    0.733155   137.425    47.0862
  3    199.860    71.5123    3.89916    0.0119685    -0.023674    0.733157   137.425    47.0776
  4    199.860    71.5123    3.89915    0.0119687    -0.023674    0.733159   137.425    47.0685
  5    199.859    71.5124    3.89914    0.0119690    -0.023675    0.733162   137.425    47.0587
  6    199.859    71.5125    3.89912    0.0119693    -0.023676    0.733165   137.425    47.0484
  7    199.858    71.5126    3.89911    0.0119696    -0.023676    0.733169   137.425    47.0375
  8    199.858    71.5127    3.89909    0.0119699    -0.023677    0.733173   137.425    47.0261
  9    199.857    71.5128    3.89907    0.0119702    -0.023678    0.733177   137.425    47.0141
 10    199.856    71.5129    3.89905    0.0119706    -0.023679    0.733182   137.425    47.0016

OBS    UZPHAT     RPFHAT     RPPHAT     WPPHAT       FPRHAT       RPTHAT     SPRHAT     UZBHAT

  1    74.9682    9.05098    10.2981    6.52970      2.63052      1.22062    6.42046    15.3625
  2    74.9700    9.05098    10.2981    6.52969      2.63052      1.22056    6.42046    15.3686
  3    74.9724    9.05098    10.2981    6.52968      2.63052      1.22050    6.42046    15.3748
  4    74.9753    9.05098    10.2980    6.52967      2.63052      1.22044    6.42046    15.3811
  5    74.9787    9.05098    10.2980    6.52966      2.63052      1.22037    6.42046    15.3874
  6    74.9826    9.05098    10.2980    6.52965      2.63052      1.22031    6.42046    15.3939
  7    74.9869    9.05098    10.2980    6.52963      2.63052      1.22024    6.42046    15.4004
  8    74.9918    9.05098    10.2979    6.52961      2.63052      1.22018    6.42046    15.4070
  9    74.9971    9.05098    10.2979    6.52960      2.63052      1.22011    6.42046    15.4136
 10    75.0028    9.05098    10.2979    6.52958      2.63052      1.22004    6.42046    15.4204
```

Table C.9--Continued

```
                               POLICY ANALSIS FOR POTATOES
                              --- EXOGENOUS VARIABLE = WN ---
                              MEAN CHANGE OF WN IS 1.6 PERCENT

OBS   NPPHAT     CRPHAT     PCMHAT     ASRHAT       CCAHAT       UCAHAT     OFPHAT     UZFHAT

  1   199.861    71.5122    3.89918    0.0119681    -0.023673    0.733153   137.425    47.0944
  2   199.837    71.5152    3.89855    0.0119785    -0.023705    0.733315   137.425    46.8168
  3   199.813    71.5182    3.89793    0.0119889    -0.023737    0.733476   137.425    46.5392
  4   199.790    71.5212    3.89730    0.0119993    -0.023769    0.733637   137.425    46.2616
  5   199.766    71.5242    3.89667    0.0120097    -0.023801    0.733799   137.425    45.9840
  6   199.743    71.5272    3.89604    0.0120201    -0.023833    0.733960   137.425    45.7064
  7   199.719    71.5303    3.89542    0.0120305    -0.023865    0.734121   137.425    45.4288
  8   199.696    71.5333    3.89479    0.0120409    -0.023896    0.734283   137.425    45.1512
  9   199.672    71.5363    3.89416    0.0120513    -0.023928    0.734444   137.425    44.8736
 10   199.648    71.5393    3.89353    0.0120616    -0.023960    0.734605   137.425    44.5960

OBS   UZPHAT     RPFHAT     RPPHAT     WPPHAT     FPRHAT     FPTHAT     SPRHAT     UZCHAT

  1   74.9681    9.05098    10.2981    6.52970    2.63052    1.22062    6.42046    15.3624
  2   75.1645    9.05098    10.2970    6.52907    2.63052    1.21981    6.42046    15.4435
  3   75.3610    9.05098    10.2959    6.52845    2.63052    1.21900    6.42046    15.5247
  4   75.5575    9.05098    10.2948    6.52782    2.63052    1.21819    6.42046    15.6058
  5   75.7540    9.05098    10.2937    6.52719    2.63052    1.21738    6.42046    15.6869
  6   75.9505    9.05098    10.2927    6.52657    2.63052    1.21657    6.42046    15.7680
  7   76.1469    9.05098    10.2916    6.52594    2.63052    1.21576    6.42046    15.8491
  8   76.3434    9.05098    10.2905    6.52531    2.63052    1.21495    6.42046    15.9302
  9   76.5399    9.05098    10.2894    6.52468    2.63052    1.21414    6.42046    16.0113
 10   76.7364    9.05098    10.2883    6.52406    2.63052    1.21332    6.42046    16.0925
```

REFERENCES

Amemiya, T. "On the Use of Principal Components of Independent Variables in 2SLS Estimation," *International Economic Review*. 7(1966): 283-303.

Ashton, R. "Fast Food: Despite Challenge, the Apocalypse Is Not Now," *Institutions*. No. 5 (May 1980): 60-66.

Bain, J.S. "Market Classification in Modern Price Theory " *Quarterly Journal of Economics*. 56(1942): 560-574.

Beilock, R.A. "A Structural Model and Simulations of the U.S. Potato Industry with Special Emphasis on Examining the Interregional Effects of Changing Energy Costs." Ph.D. Dissertation, Pennsylvania State University, 1981.

Cable, J. "Market Structure, Advertising Policy and Intermarket Differences in Advertising Intensity." K. Cowling (ed.). *Market Structure and Corporate Behavior*. London: Gray-Mills Publishing, 1972.

Cardwell, H., and R. Davis. *A Seasonal Analysis of the U.S. Potato Market*. Publication No. T-1-192, Lubbock, Texas: Texas Tech University, College of Agricultural Sciences, July 1980.

Chatterjee, S., and B. Price. *Regression Analysis by Example*. New York: John Wiley and Sons, Inc., 1977.

Christ, C. F. "Judging the Performance of Econometric Models of the U.S. Economy," *International Economic Review*. 16(1975): 54-74.

Clodius, R.L., and W.F. Mueller. "Market Structure Analysis as an Orientation for Research in Agricultural Economics," *Journal of Farm Economics*. 43(1961): 515-533.

Cochrane, W.W. "The Market as a Unit of Inquiry in Agricultural Economics Research," *Journal of Farm Economics*. 39(1957): 21-39.

Collins, N., and L. Preston. "Price-Cost Margins and Industry Structure." *Review of Economic and Statistics*. 51(1969): 271-286.

Comanor, W. S. and T. A. Wilson. "Advertising, Market Structure and Performance." *Review of Economics and Statistics*. 49(1967): 423-440.

Conrad, J. E. "Pre-Season Contract Buying--Long-Term Market Stabilizer." *Quick Frozen Foods*. No. 1 (August 1975): 30.

Corddry, P. I. "Growth to Offset Cost Increases." *Quick Frozen Foods*. No. 4 (November 1977): 154-156.

Council on Wage and Price Stability. *The Responsiveness of Wholesale and Retail Food Prices to Changes in the Costs of Food Production and Distribution*. Washington, D.C.: Staff Report, November 1976.

Cox, M. "A French Fry Diary: From Idaho Furrow To Golden Arches." *Wall Street Journal*. (February 8, 1982): 1.

Dorfman, R. and P. O. Steiner. "Optimal Advertising and Optimal Quality." *American Economic Review*. 44(1954): 826-836.

Estes, E.A. "Supply Response and Simulation of Supply and Demand for the U.S. Potato Industry." Ph.D. dissertation, Washington State University, 1979.

"Fourteenth Annual State of the Snack Food Industry Report." *Snack Food*. No. 6 (June 1982): M1-M23.

Fox, K. A. *The Analysis of Demand for Farm Products*. Technical Bulletin No. 1081, Washington, D.C.: U.S. Bureau of Agriculture Economics, September 1953.

Fox, K. A. *Econometric Analysis For Public Policy*. Ames, Iowa: Iowa State University Press, 1958.

Fromm, G. and L. R. Klein. " The NBER/NSF Model Comparison Seminar: An Analysis of Results." *Annals of Economic and Social Measurement*. 5(1976): 1-28.

Gabel, H. L. "A Simultaneous Equation Analysis of the Structure and Performance Of The United States Petroleum Refining Industry." *Journal of Industrial Economics*. 28(1979): 89:104.

Goldberger, A. S. *Econometric Theory*. New York: John Wiley and Sons, Inc., 1964.

Gomena, J. E. " Contracting of Potatoes--A Processor Viewpoint." *Eighteen National Potato Utilization Conference*. Agricultural Research Service, 74-79, February 1969.

Gray, R.W., V.L. Sorenson, and W.W. Cochrane. *An Economic Analysis of the Impact of Government Programs on the Potato Industry of the United States*. Technical Bulletin No. 211, St. Paul, Minnesota: Univ. Minn. Agr. Expt. Sta., June 1954.

Harvey, A. C. *The Econometric Analysis of Time Series*. New York: John Wiley and Sons, 1981.

Hay, D. A. and D. J. Morris. *Industrial Economics*. Oxford: Oxford University Press, 1979.

Hee, Olman. *Demand and Price Analysis for Potatoes*. Technical Bulletin No. 1380, Washington D.C.: Economic Research Service, July 1967.

Hoerl, A. E. and R. W. Kennard. " Ridge Regression: Biased Estimation for Non-orthogonal Problems." *Technometrics*. 12(1970): 55-67.

Intriligator, M. D. *Econometric Models, Techniques, and Applications*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1978.

Kendall, M. G. *A Course in Multivariate Analysis*. London: Hafner Publishing Company, 1957.

Klein, L. R. "Estimation Of Interdependent Systems In Macroeconometrics." *Econometrica*. 33(1969): 171-192.

Klein, L. R. "Forecasting and Policy Evaluation Using Large Scale Econometric Models: The State Of The Art." M. D. Intriligator (ed.). *Frontiers of Quantitative Economics*. Amsterdam Holland: North-Holland Publishing Company, 1971.

Kloek, L. R. and L. B. M. Mennes. " Simultaneous Equation Estimation Based on Principal Components of Predetermined Variables." *Econometrica*. 28(1960): 45-61.

Kluth, D. "Packing the Potato with Value." *Quick Frozen Foods*. No. 4 (November 1981): 74-76.

Lanzillotti, R.F. "The Superior Market Power of Food Processing and Agricultural Supply Firms--Its Relation to the Farm Problem." *Journal of Farm Economics*. 42(1960): 1228-1247.

Maddala, G. S. *Econometrics*. New York: McGraw-Hill. 1977.

Mann, H. M., J. A. Henning, and J. W. Meehan. "Advertising and Concentration: An Empirical Investigation." *Journal of Industrial Economics*. 16(1967): 34-45.

McClure, B. H. "The Potato Shakes Off Its Dusty Image and Regains Market Strength." *Supermarket Business*. No. 9 (September 1981): 20-22.

Mittelhammer, R. C. and J. L. Baritelle. "On Two Strategies for Choosing Principal Components in Regression Analysis." *American Journal of Agricultural Economics*, 59(1977): 336-343.

Naylor, T. H. "Policy Simulation Experiments with Macro-Econometric Models: The State Of The Art." M. D. Intriligator (ed.). *Frontiers of Quantitative Economics*. Amsterdam Holland: North-Holland Publishing Company, 1971.

Pidot, G. B. "A Principal Component Analysis of the Determinants of Local Government Fiscal Patterns." *Review of Economics and Statistics*. 51(1969): 176-188.

Pindyck, R. S. and D. L. Rubinfeld. *Econometric Models and Economic Forecasts*. New York: McGraw-Hill, 1981.

"Potato Chip Story Is Zesty Slice of Pure Americana." *Snack Food Blue Book*. New York: Harcourt Brace Jovanovich, 1976.

Potato Marketing Report. Washington, D.C.: United States Department of Agriculture, August 1972.

Purcell, W. G. "The Forecast For Frozen Potatoes." *Quick Frozen Foods*. No. 10 (May 1976): 84-85.

Sandmo, A. "On The Theory of The Competitive Firm Under Price Uncertainty." *American Economic Review*. 61(1971): 65-73.

Sawhney, P. K. and B. L. Sawhney. "Capacity-Utilization, Concentration, and Price-Cost Margins: Results on Indian Industries." *Journal of Industrial Economics*. 21(1973): 145-153.

Schmalensee, R. "Advertising and Profitability: Further Implications of the Null Hypothesis." *Journal of Industrial Economics*. 25(1976): 45-54.

Schmidt, P. *Econometrics*. New York: Marcel Dekker, Inc., 1976.

Scott, F. E. and H.W. Mumford. *Problems in Marketing Potatoes, Preliminary Results of Some Recent Research*. Washington, D.C.: U.S. Department of Agriculture, 1949.

Shepherd, G.S. and G.A. Futrell. *Marketing Farm Products*. 5th ed., Ames, Iowa: Iowa State University Press, 1969.

Shuffett, D. M. *The Demand And Price Structure For Selected Vegetables*. Technical Bulletin No. 1105, Washington, D.C.: U.S. Department of Agriculture, 1954.

Simmons, W. M. *An Economic Study Of The U.S. Potato Industry*. Agricultural Economic Report No. 6, Washington, D.C.: U.S. Department of Agriculture, March 1962.

"Simplot--Today and Tomorrow." *Quick Frozen Foods*. No. 11 (June 1977): 37-78.

Strickland, A. D. and L. W. Weiss. " Advertising, Concentration and Price-Cost Margins." *Journal of Political Economy*. 84(1976): 1109-1121.

Summers, L. V. and C. Drury. *Marketing Northwest Potatoes*. Technical Bulletin No. 529, Moscow, Idaho: University of Idaho, Idaho Agricultural Experiment Station, 1971.

Sutton, C. J. " Advertising, Concentration and Competition." *Economic Journal*. 84(1974): 56-69.

Talburt, W. F. and O. Smith. *Potato Processing*. Westport Conn.: The AVI Publishing Company, 1975.

"The American Consumer." *Restaurant Business*. No. 6 (May 1982): 149-186.

Tinbergen, J. *Economic Policy: Principles and Design*. Amsterdam: North-Holland Publishing Company, 1956.

U.S. Bureau of Census. *Census of Business, Retail Trade--Geographic Area Series, 1958-77*.

U.S. Department of Agriculture. *Food Consumption of Households in the United States*. Household Food Consumption Survey Report, 1955.

U.S. Department of Agriculture. *Potatoes and Sweetpotatoes, by States and Seasonal Groups--Crops of 1950-1980*. Washington, D.C., 1982.

Ward, R. W. "Asymmetry in Retail, Wholesale, and Shipping Point Pricing for Fresh Vegetables." *American Journal of Agricultural Economics*. 64(1982): 205-212.

Ward, R.W. and R. M. Behr. "Revisiting the Advertising-Concentration Issue." American Journal of Agricultural Economics. 62(1980): 113-117.

Warwick, C. "Responsibility for Freshness." Snack Food. No. 10 (October 1971): 63-65.

Warwick, C. "A Better Way To Stay in Business." Snack Food. No. 5 (May 1973): 50-51.

Waugh, F. V. Demand and Price Analysis--Some Examples From Agriculture. Technical Bulletin No. 1316, Washington, D.C.: U.S. Department of Agriculture, 1964.

Weiss, L. W. and J. J. Siegfried. "Advertising, Profits and Corporate Taxes Revisited." Review of Economic and Statistics. 56(1974): 195-200.

Williamson, O. E. "Selling Expense as a Barrier to Entry." Quarterly Journal of Economics. 77(1963): 112-128.

Zellnor, A. and H. Theil. "Three-Stage Least Squares: Simultaneous Estimation of Simultaneous Equations." Econometrica. 30(1962): 54-78.

Zusman, P. "Econometric Analysis of The Market for California Early Potatoes." Hilgardia. 33(1962): 539-668.

BIOGRAPHICAL SKETCH

Eugene Jones was born on December 19, 1951, in Eufaula, Alabama. He completed his high school education in Eufaula in 1969 and entered Tuskegee Institute in 1970. During his studies at Tuskegee, he met and later was married to Jacqueline Johnson.

After completing his studies at Tuskegee in August, 1973, he joined the Agency for International Development (AID) as a junior economist. AID provided funding for him to pursue a master's degree at the American University in Washington, D. C. After obtaining his M.A. in economic development from American University, he began his Ph.D. studies at the University of Florida in September, 1976.

He interrupted his studies in 1979, to accompany his wife to St. Louis, Missouri, for her residency in internal medicine. While in St. Louis, he worked for the city government and an Illinois regional planning agency. He returned to the University of Florida in August, 1981, and has worked for the United States Department of Agriculture while completing his studies.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Ronald W. Ward

Ronald W. Ward, Chairman
Professor of Food and Resource
Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Richard L. Kilmer

Richard L. Kilmer
Associate Professor of Food and
Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Woodrow W. McPherson

Woodrow W. McPherson
Graduate Research Professor of
Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Frank G. Martin

Frank G. Martin
Associate Professor of
Statistics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Glenn A. Zepp
Glenn A. Zepp
Associate Professor of Food and
Resource Economics

This dissertation was submitted to the Graduate Faculty of the College of Agriculture and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August 1984

G. L. Zachariah
Dean, College of Agriculture

Dean for Graduate Studies and
Research

UNIVERSITY OF FLORIDA
3 1262 08554 0846